PRODUCT ENGINEERING

MARCH, 1939

3 "WAYS" *agree on* 1 FACT

MODERN METALS REDUCE OPERATING COSTS

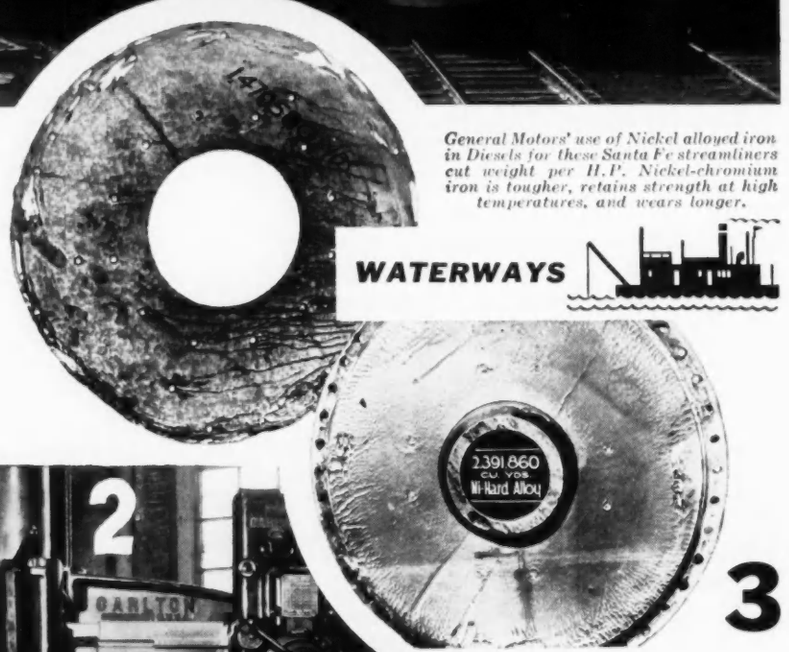
RAILWAYS

General Motors' use of Nickel alloyed iron in Diesels for these Santa Fe streamliners cut weight per H.P. Nickel-chromium iron is tougher, retains strength at high temperatures, and wears longer.

Railways, highways and waterways present varied operating problems. But each transport system agrees operating costs can be reduced by utilizing modern materials—such as Nickel alloyed cast irons.

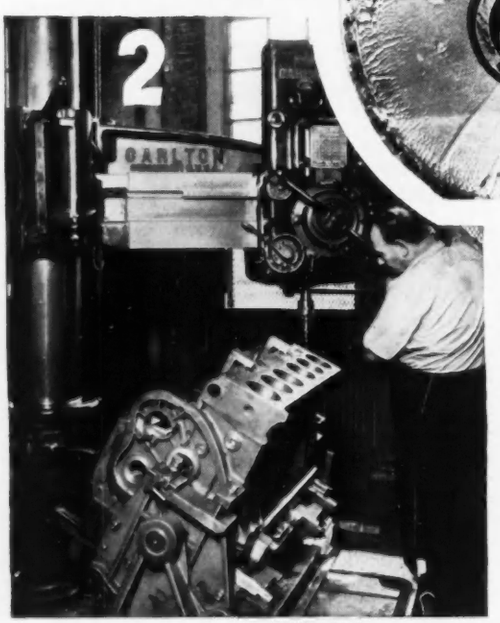
For new equipment or replacement parts, take full advantage of the money-savings made possible by modern metallurgy and engineering. Make each ounce, each inch of metal carry bigger loads, resist harder wear, by specifying the correct alloy strengthened and toughened with Nickel.

NICKEL CAST IRONS



28-inch dredge liners used at Ft. Peck Dam. Under identical conditions the liner at left above, rolled from plain steel wore out after handling less than 1½ million cubic yards. The liner at right above cast from Ni-Hard—the abrasion-resistant Nickel iron—withstood 2-1/4 million yards and after inspection it was put back in service to add millions more yards to its career.*

WATERWAYS



Mack Mfg. Corp. casts these heavy duty truck cylinder blocks in their own foundry from Nickel alloyed iron. Nickel increases machinability, permits drilling at speeds 1½ times faster than in other irons of same hardness.

HIGHWAYS

*Reg. U. S. Pat. Off. by The International Nickel Company, Inc., Canadian Patent No. 281986

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

PRODUCT ENGINEERING

What's Coming—April P. E. will present the largest and most comprehensive group of reference charts, tables and design standards that have ever appeared in one number. Among the subjects covered will be vibration dampers, oilless bearings, steel casting design standards, properties and applications of copper and brass alloys, types of wrinkle finishes, compression-spring adjusters, flexible shaft end mountings, tables for obtaining WR^2 monograms, for cold-molded materials, and many others.

And in addition to all this the annual comprehensive directory of sources of supply for engineering materials and parts—completely revised and brought up-to-date.

Cover Picture—Automatic machine for putting cellophane hoods on milk bottles and fastening the hood with heat-sealed tape. Photo. courtesy Package Machinery Co. See page 98 for detailed description.

N. O. WYNKOOP, *Publisher*
G. F. NORDENHOLT, *Editor*

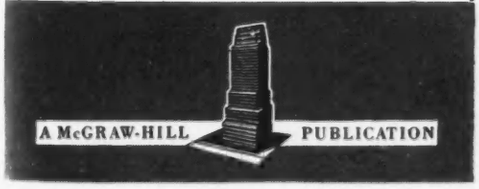
K. H. CONDIT, Consulting Editor
JOSEPH KERR, Associate Editor
JOHN SASSO, Assistant Editor
R. R. WIESE, Western Editor
PAUL WOOTON, Washington
H. S. KNOWLTON, Boston
W. F. KENNEDY, Manager

Published monthly. Price 35c a copy. Subscription rates — United States, Canada, Mexico, Central and South American countries $3 a year. All other countries, $5 a year or 20 shillings. Entered as second-class matter August 21, 1936, at Post Office, Albany, N.Y., under act of March 3, 1879. Printed in U.S.A. Publication Office, 99-129 North Broadway, Albany, N.Y. Editorial and Executive Offices, 330 West 42d Street, New York, N.Y.

Branch Offices: 520 North Michigan Avenue, Chicago; 883 Mission Street, San Francisco; Aldwych House, Aldwych, London, W.C.2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga. Cable Address: MCGRAWHILL, New York. Member A.B.P. Member A.B.C.

COPYRIGHT 1939, BY
McGRAW-HILL PUBLISHING CO., INC.
JAMES H. McGRAW
Founder and Honorary Chairman

JAMES H. McGRAW, JR., President
HOWARD EHRLICH, Executive Vice-President
B. R. PUTNAM, Treasurer
MASON BRITTON, Vice-Chairman
D. C. McGRAW, Secretary
J. E. BLACKBURN, JR., Circulation Manager



VOLUME 10 MARCH, 1939 NUMBER 3

Ball Bearing Troubles 88

THOMAS BARISH—How to detect causes of damage resulting from improper mounting or operating conditions.

Modern Designs 94

Pictorial presentations of salient design features in a representative group of current-model products and machines.

Electronic Inspection Devices 101

G. C. DEVOL, JR.—Scanning systems and electronic circuits for detecting variations in products and colored surfaces.

High Temperature Design 104

E. A. DAVIS—How to interpret and apply creep data in designing member for high-temperature service.

Plastics Over Metal 107

C. H. WHITLOCK—How to design parts to be made of metal and covered with cellulose acetate.

Gear Calculations—II 109

A. C. RASMUSSEN—Development of gear tooth formulas for bevel gears based on dynamic loading.

Ceramic Parts 111

HAROLD G. BEEBE—Typical mechanical and electrical applications in machines and instruments.

Compression Spring Adjusting Methods—I 114

HENRY MARTIN—Various designs of screw and nut adjustment, some with spring-centering means to guard against buckling.

Magnet Coils 129

GRAHAM L. MOSES—Formulas for calculating air gap pull and general construction details of magnet spools.

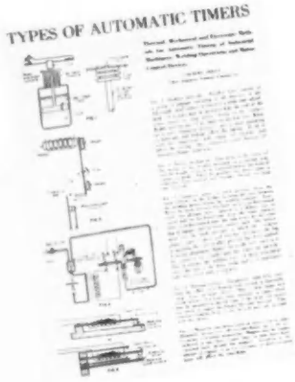
Editorial 87
Question and Comment. 116
News 119
New Materials and Parts 122
Manufacturers' Publications 127
Books and Bulletins.... 128

Coming in April

THE ANNUAL

REFERENCE AND DIRECTORY NUMBER

A larger and more valuable issue featuring three outstanding sections . . .



EDITORIAL—The editors are preparing over 40 pages of "high reference" material on more than a dozen different subjects. Each will be presented in the condensed, informative style that makes for quick and easy reference. It's going to be just the kind of material you will want at your finger-tips all during the year.

DIRECTORY—In a separate section, there will be another specialized and authoritative Where-to-Buy Directory of over 50 pages. It's the only Directory in which the headings are especially chosen to aid product engineers in selecting sources of parts, materials, and finishes. Also, listings on engineering-department supplies and accessories that you regularly use in your work will occupy several pages at the end of this Directory section.

ADVERTISING—And, of course, many pages of advertising will supplement the editorial and Directory sections—giving you further information on the products in which you are interested. Much of it will be of the catalog and reference type "tied-in" with the theme of this annual issue. Listings of all advertisers will appear in the Directory in bold-face type so that you can quickly refer to the advertising on items you need.

PROMINENT PRODUCT ENGINEERS HAVE FOUND IT PAYS

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *EDITOR*

McGRAW-HILL PUBLISHING CO., INC. MARCH, 1939 VOLUME TEN, NUMBER THREE

The Whole Truth Is More Convincing

RECENTLY THE 41½-ton, 73-passenger Boeing plane, designed and built for transatlantic service, passed its Civil Aeronautic Authority acceptance tests, a necessary prerequisite before the ship could be put in service. In celebration of this event, Pan American Airways put on a half-hour radio broadcast wherein outstanding men of the air-transportation industry spoke. As was to be expected, a great deal of attention was given to stressing the safety and dependability of modern aircraft in general and this new Boeing plane in particular.

This new Boeing ship is much bigger than previous airplanes. And the public is usually skeptical about things radically new. Perhaps it was for these reasons that several of the speakers emphasized the thought that the design of the ship did not involve any new principles but was based on the aeronautical design knowledge accumulated since the invention of the airplane by the Wright brothers.

As so frequently happens, over-emphasis may result in creating the opposite impression. Listening to the broadcast, one might have gotten the impression that the design of this 41½-ton airplane was merely a matter of the arbitrary application of handbook formulas and the making of draftsman's tracings of standardized layouts. Yet that is far from the idea that was intended to be conveyed and even a layman completely ignorant of engineering procedure in the design of aircraft must have sensed that this great and wonderful new ship required a good deal of original engineering work.

Engineers in general recognize that aeronautical design holds by a wide margin the first rank in engineering. They know about the work of the stress analysts who painstakingly calculate the effects of every conceivable type of load to which the members might be subjected. It is generally known that full size and scale models are built and subjected to numerous tests to determine their strength, detect their weaknesses and check the work of the stress analysts. Guesses and assumptions concerning the final design are not permitted. Every detail must stand the acid test of performance.

Likewise, in the manufacture of airplanes, exactness and quality are demanded and attained to a degree that is not equalled in any other industry. Tens of thousands of separate inspections are made in the course of the manufacture of one airplane engine and the final running test to which it is subjected is far more gruelling than anything to which it may be subjected in ordinary flight.

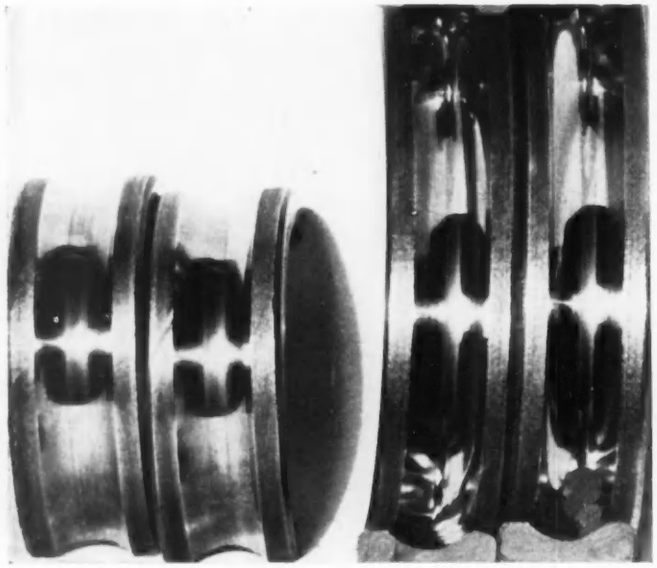
At least to an engineer it seems that it would have been more appropriate, convincing and effective if the speakers on Pan American's broadcast had omitted all reference or allusion to any thoughts that this 41½-ton ship did not require the solution of new design problems—which it certainly must have. Instead, they might have in a few brief words stressed the great dependability of the wonderful engineering achievement and dramatically mentioned how painstakingly and accurately the work was accomplished and how every detail was checked by repeated tests. Such being the frank and open truth, it would have been much more convincing, if properly presented. And the Boeing engineers would have received at least a crumb of the great credit which is due them.

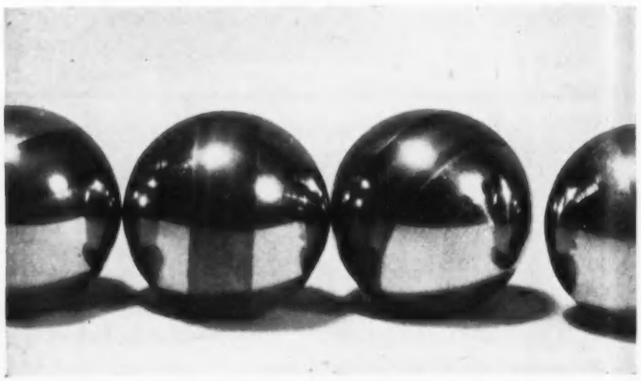
BALL BEARING TROUBLES

How to Determine Causes by Examining Bearings

THOMAS BARISH
Assistant Chief Engineer, Marlin-Rockwell Corporation

More than 95 per cent of all ball bearing troubles investigated resulted from defective mounting, improper operating conditions and similar causes which can usually be detected by visual inspection of the bearing





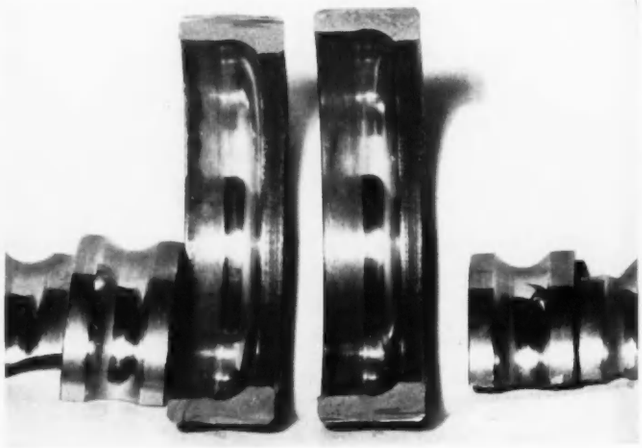


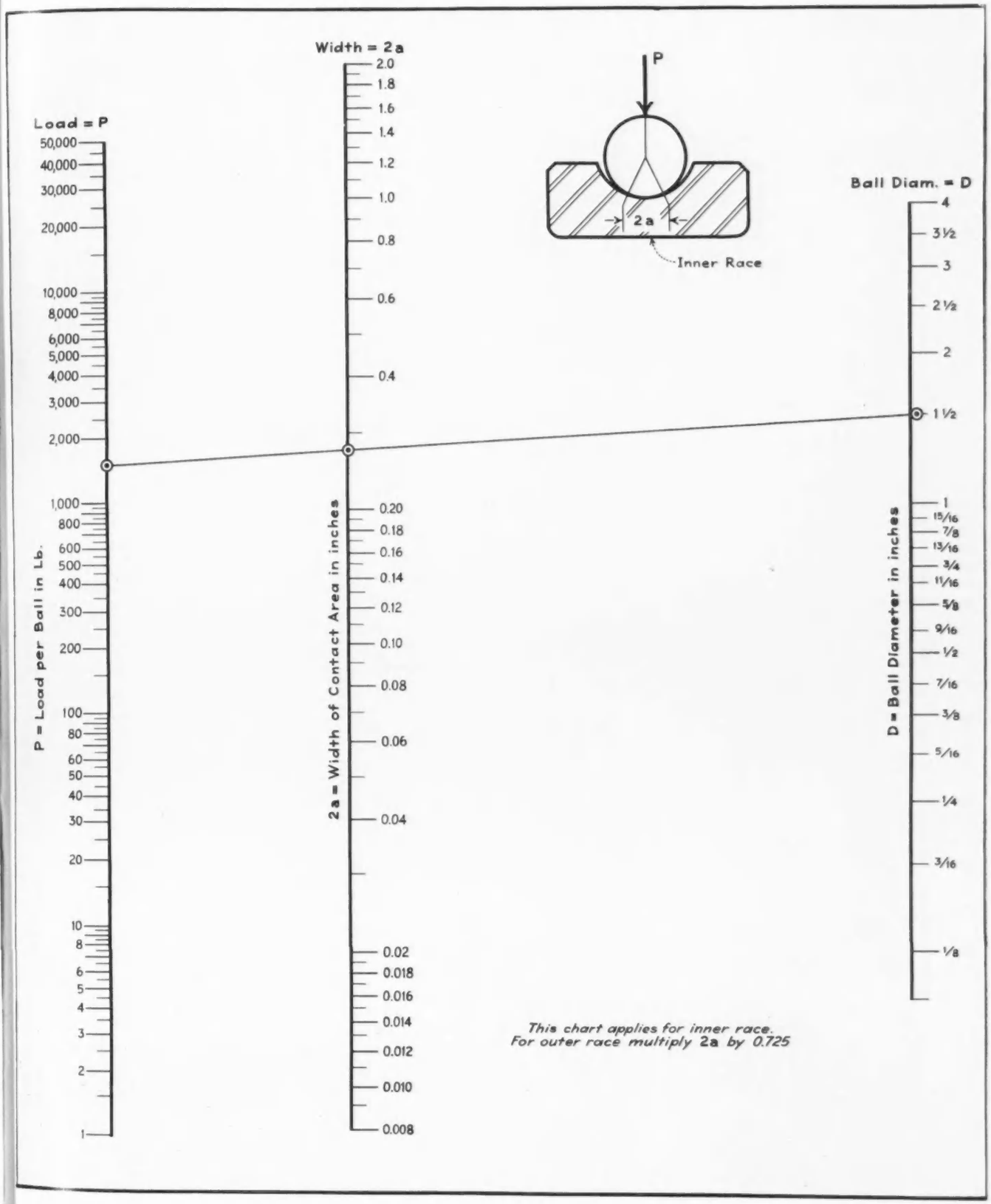
Fig. 1—Absence of trouble in a bearing that has operated under radial load can easily be recognized. As in these bearings which evidently were properly mounted, operated under good load conditions, kept clean and properly lubricated, the path of the balls in the highly polished races shows as a dulled surface similar to a lapped surface, wherein the microscopically find grinding scratches have been smoothed out. There has been no appreciable removal of material from the surface, as indicated by the fact that there has been no measurable decrease in the diameter of the balls, though their entire surface has been dulled.

Other indications that operating conditions have been satisfactory are the uniformity of the ball paths, their exact parallelism with the side of the races, indicating correct alignment, and the centering of the ball track in the race, this indicating that the bearing carried a purely radial load. Normally, the outer race, if fixed, should carry load for less than half the circumference, but in this instance either the load rotated or, more likely, the outer race crept slightly in the housing, thus distributing the ball contact around the entire circumference.

Fig. 2—Angular-contact bearings that have operated a considerable length of time under ideal conditions, carrying a pure thrust load, show the ball path riding the sides of the race, approaching the edge of the shoulder but not reaching it. If the radial-type bearing shown in Fig. 1 had been carrying a thrust load, its ball path would have been off-center, but not as much as shown here for the angular- contact bearing.

If operating conditions are correct, the balls in angular-contact bearings will have their entire surfaces dulled, appearing just like the ball paths, but with one important exception. If a thrust load has been present continuously for the entire period of operation and if it was large enough relative to the radial load to keep the balls in contact at all times, the balls will show a circumferential band as in illustration above, indicating that: (1) The balls did not normally spin or change their axis of rotation; (2) The fatigue life of the balls has been reduced because of the small area of ball surface used; (3) If the bands have appreciable depth there has been material wear caused by improper operating conditions. If when operating under conditions that cause circumferential bands, the bearing setting were disturbed or the load were removed or shifted, the axis of spin of the balls would shift, causing immediate roughness or noisy operation if the balls have been worn appreciably.

Fig. 3—The magnitude of the load which a bearing has supported can be determined roughly from measurements of the bearing provided the conditions of operation have been approximately as good as shown in Fig. 1 or Fig. 2. The ball contact area, sometimes erroneously considered a point, is actually a long narrow ellipse, the major axis of which is exactly equal to the width of the ball



path as shown in Fig. 1 or Fig. 2. From this dimension, the diameter of the ball and the geometry of the bearing, the nomogram above can be used to determine the actual load per ball. This figure multiplied by the total number of balls in the bearing and divided by 4.25 will give the total radial load supported by the bearing. Likewise for total thrust load find the load per ball as determined from the chart in the same manner as for radial bearings, and multiply by the number of balls and then multiply the resulting quantity by the sine of the contact angle which can be determined from the position of the ball path. Loads as determined will be only approximations because minor variations in alignment, small shaft deflections, or slight amounts of foreign matter will make the ball path appear wider than it actually is and thereby the load as calculated by the chart will be higher than the load actually carried. *(More on next page)*

Damage Caused by Foreign Matter

BALL BEARINGS are particularly sensitive to dirt or foreign matter, which is always more or less abrasive, because the very high unit pressure between the ball and race and because of the rolling motion which tends to entrap the pieces, particularly if they are small.

In the minds of some, blaming unsatisfactory operation of ball bearings on "foreign matter" is merely an alibi of the bearing manufacturer. But the fact is that this is most common cause of damage to ball bearings. The foreign matter may get into the bearing during the initial assembly of the machine, during repairs, by seepage from the atmosphere into the bearing housing during operation of the machine or it might even get in as adulterants in the lubricant.

The character of the damage caused by different types of foreign matter getting into ball bearings varies considerably with the nature of the foreign matter. Fine foreign matter or foreign matter that is soft enough to be ground fine by the rolling action of the balls will have an effect the same as that which results from the presence of a fine abrasive or lapping material. The races become worn in the ball paths, the balls wear and the bearings become loose and noisy. The lapping action increases rapidly as the fine steel removed from the bearing surfaces adds more lapping material.

Hard coarse foreign matter such as iron, steel or other metallic particles introduced when assembling the machine, produce small depressions of a character considerably different from those produced by overload failure, acid etching or corrosion. Jamming of the hard particles between the balls and the races may cause the inner race to turn on the shaft or the outer race to turn in the housing.

Water, acid or other corrosive materials, or corrosives formed by deterioration of the lubricant, produces a type of failure that is indicated by a reddish brown coating and very small etched holes over the entire exposed surface of the races. Frequently the etching does not show on the ball path because the rolling action of the balls pushes the lubricant, loaded with corrosive, away from the ball path. The corrosive oxides formed act as lapping agents that cause wear and produce a dull gray color on the balls and the ball paths, as contrasted with the reddish brown color of the remainder of the surface.

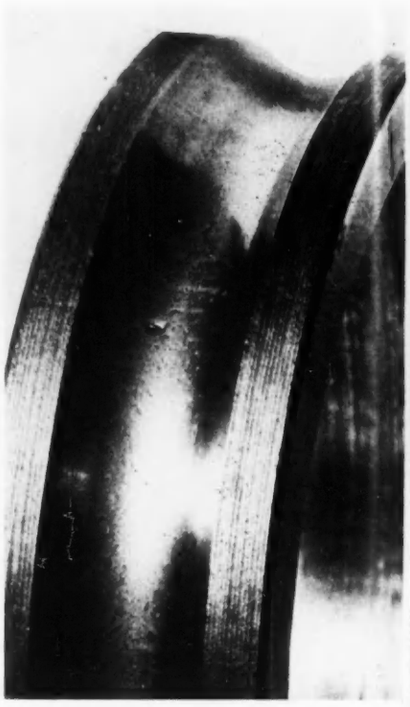


Fig. 5—Hard coarse foreign matter causes small depressions with rounded edges and of various sizes, a type of depression differing considerably from that produced by overloads or corrosion.

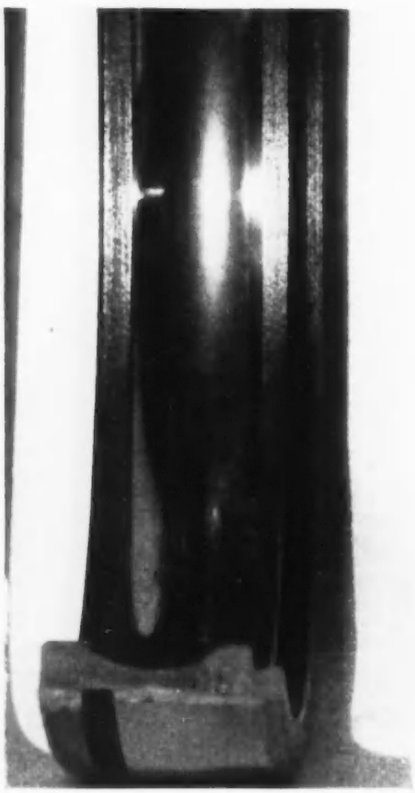


Fig. 4—Fine foreign matter in the bearing laps the ball surfaces and ball races, the wear causing the bearings to become loose. In this bearing the balls were worn 0.002 in. undersize, though still almost perfectly round.

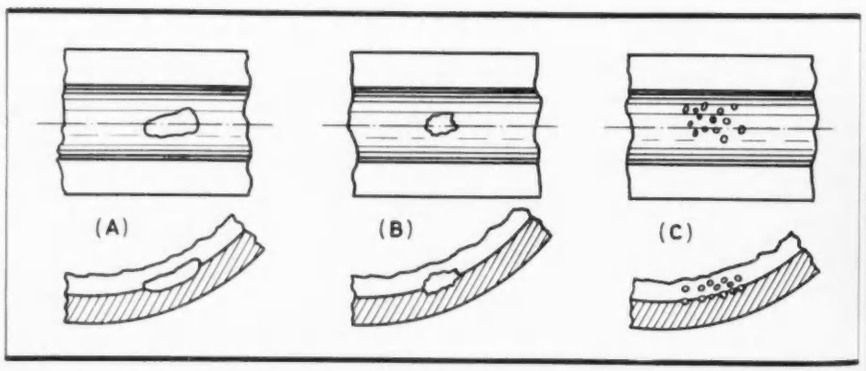


Fig. 6—Three types of race surface deterioration (A) Hard coarse foreign matter causes rounded depressions; (B) Overloads cause fatigue failure characterized by sharp jagged edges; (C) Etching causes hemispherical depressions.

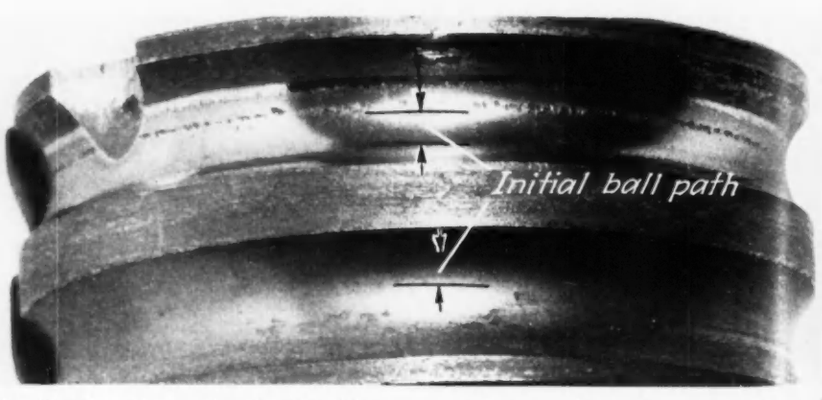


Fig. 7—Corrosion makes itself evident over the entire exposed surface of the race as a reddish brown coating and small etched holes.

Damage Caused by Overloads

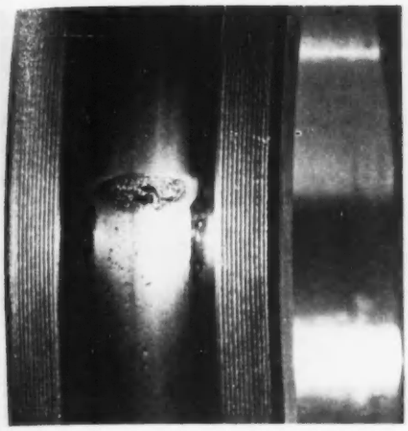


Fig. 8—Overload causes fatigue failure of the material as evidenced by the breaking out of the surface layer of steel. Such a failure starts in a small area and spreads rapidly and would eventually spread over both the races and the ball surfaces. Most frequently failure starts on inner race. Here the wide ball path is added indication of excessive loading.

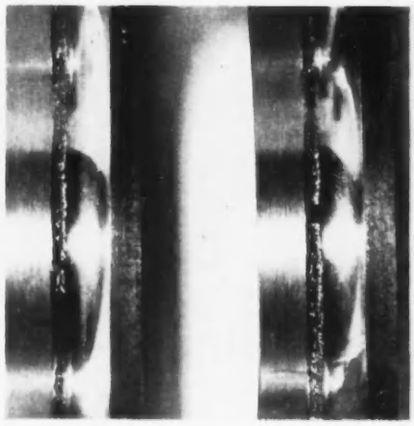


Fig. 9—Effect of a thrust load in the wrong direction on an angular contact ball bearing. The balls rode on the edge of the race groove where it joins the shallow shouldered counterbore and thus broke up the race surfaces. Under these conditions the balls will frequently break up or split, even though their material and heat-treatment was perfect.

Misalignment and Off-Square

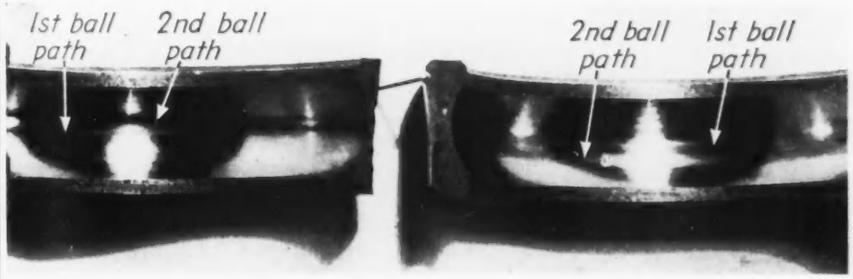


Fig. 10—Outer race of a ball bearing that operated for a short time in perfect alignment and then something happened to force the race into an off-square position. The two distinct periods of operation are clearly distinguishable. Though this bearing was made with specially flattened race curvature to give increased tilting capacity, the tilting was enough greater to jam the balls into the race groove hard enough to start a fatigue failure. Measurement of the damaged bearing showed that over 3 deg. tilt, $\frac{5}{8}$ in. per ft., could take place before the balls would jam into the second or off-square ball path.

Fig. 11—A conventional single row bearing that had been subjected to off-square operating conditions. The outer race ball path clearly moves from the right hand side over to the left and back again. The ball path was a full $\frac{1}{8}$ in. off-square in about a 3 in. diameter raceway. The ring itself was tilted only about $\frac{1}{4}$ in. but produced a greater change in the ball path because of the change in contact angle. The inner race had a very wide ball path since the ball wandered back and forth across nearly its full width.

Only the retainer in this bearing showed deterioration. Neither race failed except for a slight roughening from the metallic particles which came off the separator. The retainer cracked and then broke as shown. In fact, almost all separator failures in a standard single row type of ball bearing can be traced back to an off-square condition of either inner or outer race. The failure is caused by variations in ball speed jamming the balls into the separator pockets.

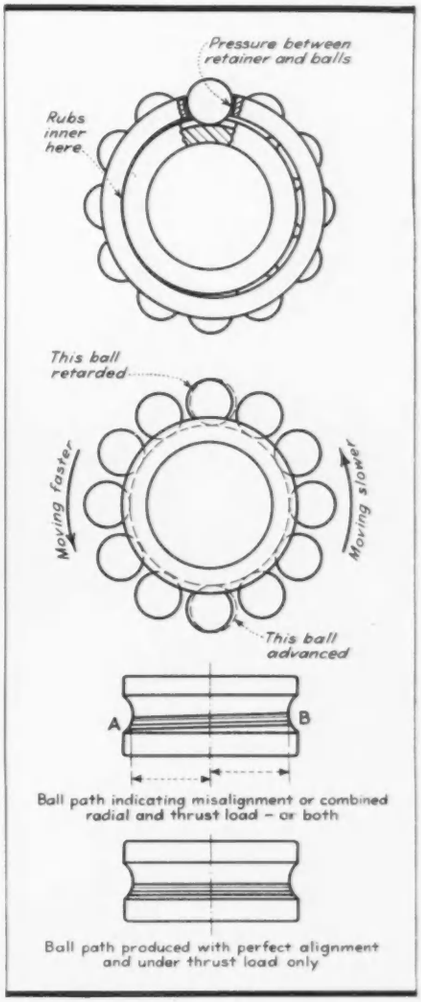

Pressure between retainer and balls
Rubs inner here
This ball retarded
Moving faster
Moving slower
This ball advanced
A
B
Ball path indicating misalignment or combined radial and thrust load – or both
Ball path produced with perfect alignment and under thrust load only

Fig. 12—Ball speed variation caused by off-square operation, produces the greatest effect when the balls are never free to readjust themselves, as in a tight bearing or in a bearing carrying mainly thrust load. The variation in ball speed is then accumulative and the two side balls force the retainer downward until it strikes the inner or outer race. Outer race tilting can

be easily determined in operation, being evidenced by the eccentrically operating retainer. With inner race cocking, the eccentricity of the retainer rotates with the inner race.

Fig. 13—A solid retainer which had been forced to rub the inner race in the manner just described and to the extent of removing about $\frac{1}{32}$ in. of metal from the bore of the retainer. The ball pockets have also been gouged out considerably and all because of excessive tilt of inner or outer races. Such conditions are first evidenced by heat resulting from excessive binding of retainer and by small steel or bronze chips breaking off the retainer and appearing in the lubricant.

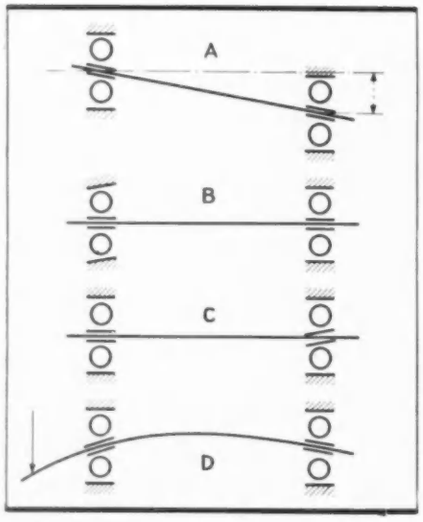


Fig. 14—Four types of misalignment to which ball bearings may be subjected. (A) Out-of-line conditions rarely cause trouble. The usual single row ball bearing, not self-aligning type, can withstand $\frac{1}{4}$ deg. angular movement, $\frac{1}{16}$ in. per foot, and if matched slightly looser than standard will take up to about $\frac{1}{2}$ deg. angle, $\frac{1}{8}$ in. per foot, without cramping or binding. A shaft a foot long out-of-line by more than $\frac{1}{16}$ in. would be very unusual. (B) It is far more common to find the bearing housing or the housing shoulder tilted or off-square. (C) It is also common to have the shaft shoulder tilt the inner race. Under conditions (B) and (C) the same angularities are produced by much smaller errors. On a 1-in. diam. shaft a 0.005 in. off-square shoulder corresponds to $\frac{1}{4}$ deg. angular misalignment. (D) Shaft deflections rarely matter because shafts will usually break before the angularity at the bearing reaches $\frac{1}{4}$ deg. The exceptions occur only on long shafts where diameters are reduced to an absolute minimum, as on automobile rear wheels or airplane engine crankshafts.

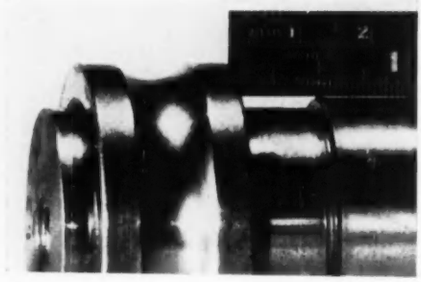


Fig. 15—Inadequate shaft shoulders can be crushed down on one side by the corner radius of the bearing and leave the inner race tilted on the shaft. The corner radius is not always square with the ground exterior surfaces of the bearing, since the corner is just turned and is not ground after heat-treating. Hence, shaft and housing shoulders should be deep enough to contact the ground side surfaces of the bearing.

Brinelling and False Brinelling

A FEW BALL BEARINGS are brinelled when putting them on the shaft by being struck a severe blow or by extremely heavy pressure. But this is rare because most ball bearings have enough thrust capacity, at 10 r.p.m. to permit forcing them onto the shaft by pressure against the outer race, provided the pressure is applied squarely. The exceptions are the smallest bearings and bearings with flatter races such as propeller shaft center support ball bearings and self aligning types. The rare occasions when regular single row ball bearings are brinelled usually result from off-center blows or pressure when only 3 or 4 balls carry the entire load.

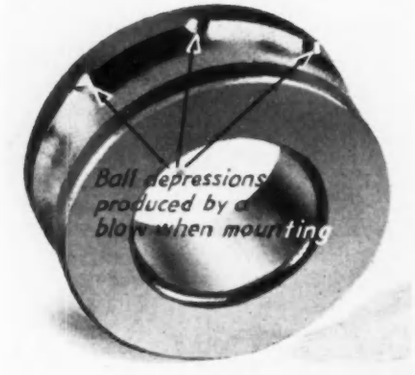


Fig. 16—Brinelling of bearing caused by off-center blow in mounting. Only three balls produced depressions, the center mark being the deepest. Shallower marks frequently go unnoticed because the edges of the brinelled depression are not clearly marked and no change appears in the surface of the raceway itself. Hence they are difficult to see under a microscope. Such bearings frequently go unnoticed in operation because load does not cause the ball path to reach the brinell marks on the races. However, the balls acquire similar depressions and will make the bearing sound noisy or "catchy," as though it had several small pieces of foreign matter in it. Failure may result at the flat spots on the balls or will occur on the races if carrying heavy enough thrust load for the ball path to reach the brinell marks.

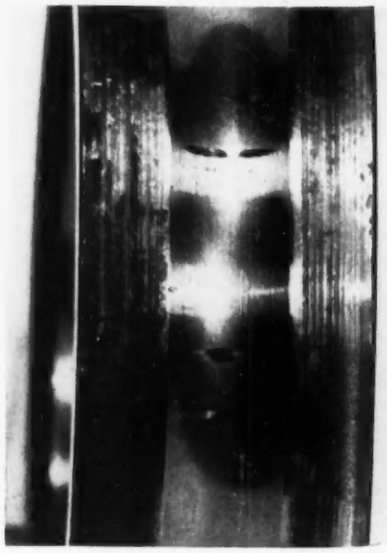


Fig. 17—"False Brinelling" occurs when bearings do not rotate for extensive periods. Loads may be relatively

light but slight changes in the surfaces of the raceways result from even minute axial or rotational movements and these only appear under each ball. This bearing, which shows 5 sets of markings, served as a dynamometer support for approximately 3 years. The shape of the so-called "point contact" of a ball bearing is shown clearly, although the ellipse has been lengthened and broadened by the small axial rotational movements of the balls.

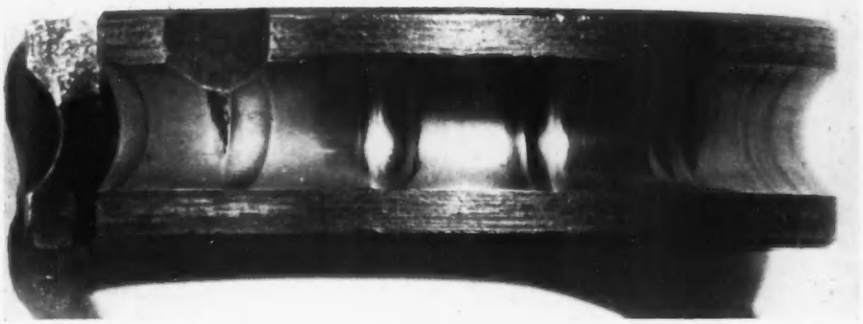


Fig. 18—False brinelling pockets occur in the presence of vibration without rotation and can be very greatly deepened by abrasive foreign matter. Exposing the bearing surfaces to air will oxidize the microscopic metal particles freed by the vibrating movement and these oxides in turn provide the abrasive action as in the extreme example shown here. Some discussion has arisen as to whether the abrasion or the oxidation starts first, but the results are the same.

False brinelling produces surface depressions far more rapidly when balls actually skid or slide on the race surfaces instead of just rolling; examples—large axial vibrations in ball bearings or centrifugal forces on loose balls in controllable-pitch propeller bearings.

A thorough technical analysis of this subject was presented by J. E. Almen in *Mechanical Engineering*, June, 1937, and discussions by the author and Mr. Almen in the September, 1937, issue.

Damage Caused by Heat

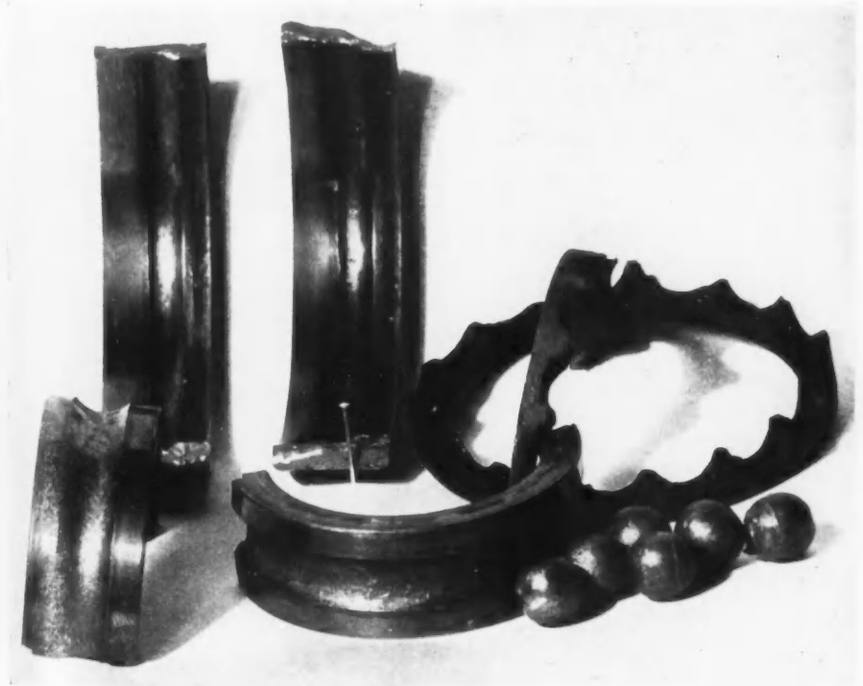


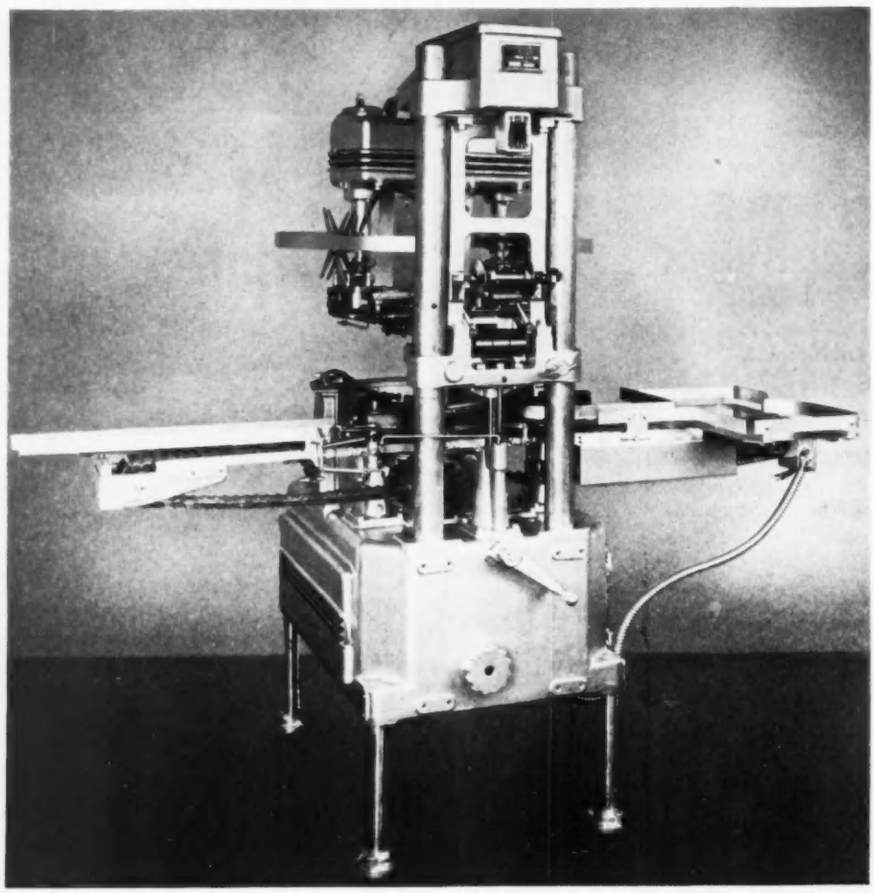
Fig. 19—Heat failures occur only at medium and high speed operations. The initial cause is frequently obscured especially at the highest speeds and may be: (1) Failure of lubricant by lubricant source being cut off, lubricant deterioration or contamination. (2) Excessive load. (3) Cramped bearings, either radially tight bearings caused by expansion of inner race when pressing on shaft or expansion of outer race when pressing on housing, or axially tight by squeezing one bearing against another; (4) Off-square producing heat at retainer; (5) Heat from an external source.

Sometimes the initial cause may be diagnosed by noting which parts showed the initial heating, the most heating or by other similar indications.

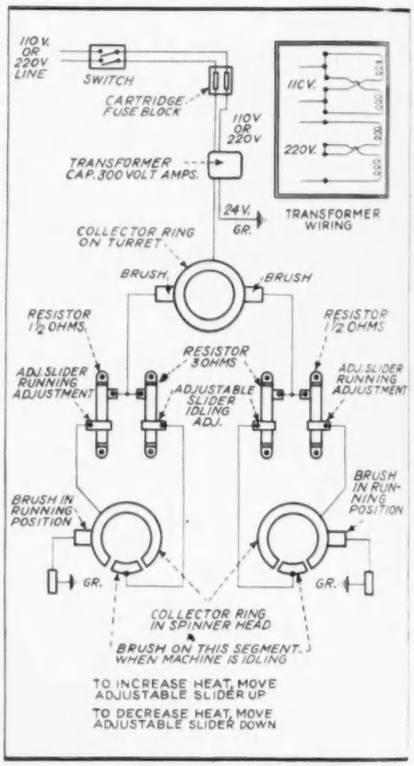
Fig. 20—Heat will not only badly oxidize separators but will also soften the balls and races, and particularly the balls because the heat cannot be conducted away from them as rapidly as from the races. Liberal lubrication may make possible continued operation for some time in spite of the partly softened balls and races, and the high centrifugal forces cause the metal to flow. Thus sometimes balls are produced that are hollow, causing the wrong assumption that they were made that way.

Modern Designs

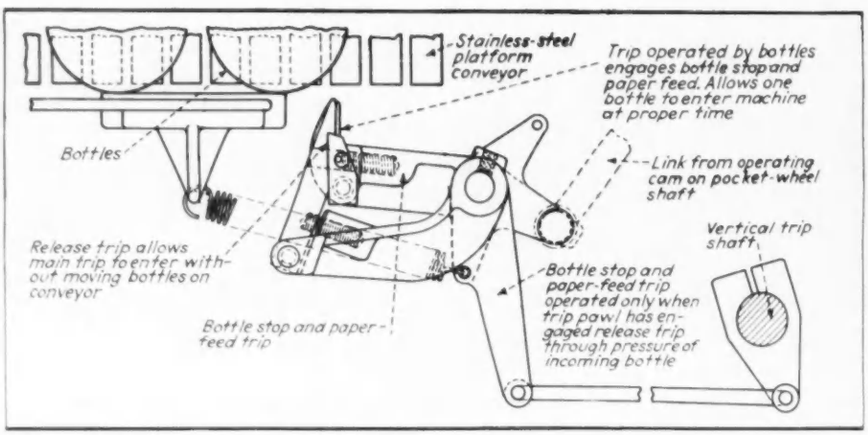
Ingenious Feed Interlock, Adjustable Heat-Sealing in New Bottle Hooder



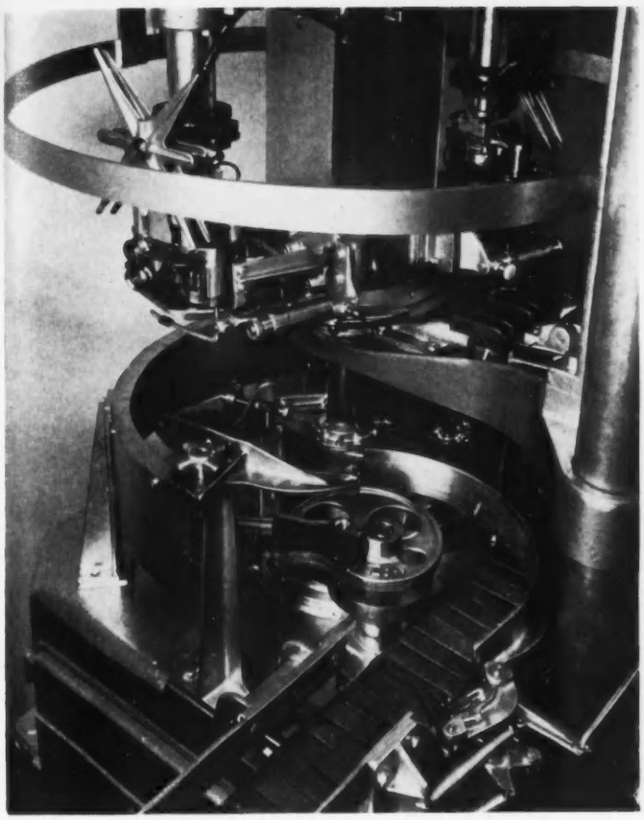
Built of corrosion-resistant materials, this new machine, developed by Package Machinery Company, E. Lovell Smith, chief engineer, will handle any standard size of milk bottle. Bottles fed from a stainless steel plane surface conveyor chain are hooded with cellophane. Hood is fastened with heat-sealed tape.



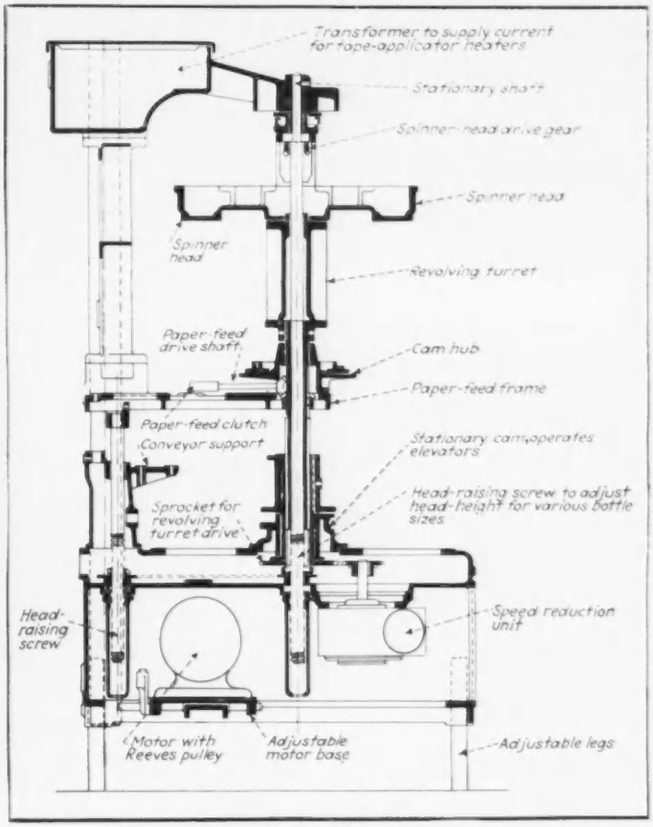
Tape-sealing heaters cannot overheat when machine is idle. In stop position, heater brush on tape reel bracket contacts small low-voltage section of the collector ring, which has its resistor set to 50 watts. When machine runs, brush contacts the larger higher-voltage segment through which 70 to 150 watts are available for tape-fastening heat.


Stainless-steel platform conveyor
Trip operated by bottles engages bottle stop and paper feed. Allows one bottle to enter machine at proper time
Bottles
Link from operating cam on pocket-wheel shaft
Vertical trip shaft
Release trip allows main trip to enter without moving bottles on conveyor
Bottle stop and paper-feed trip operated only when trip pawl has engaged release trip through pressure of incoming bottle
Bottle stop and paper-feed trip

No bottle—no cellophane. Cellophane feed is interlocked with bottle feed. As bottle contacts paper feed trip on conveyer, it causes the pawl on the trip lever operated by cam on pocket wheel shaft to engage pawl on paper-feed trip lever, thus opening trip. This allows bottle to enter the pocket wheel, and simultaneously starts cellophane feed.

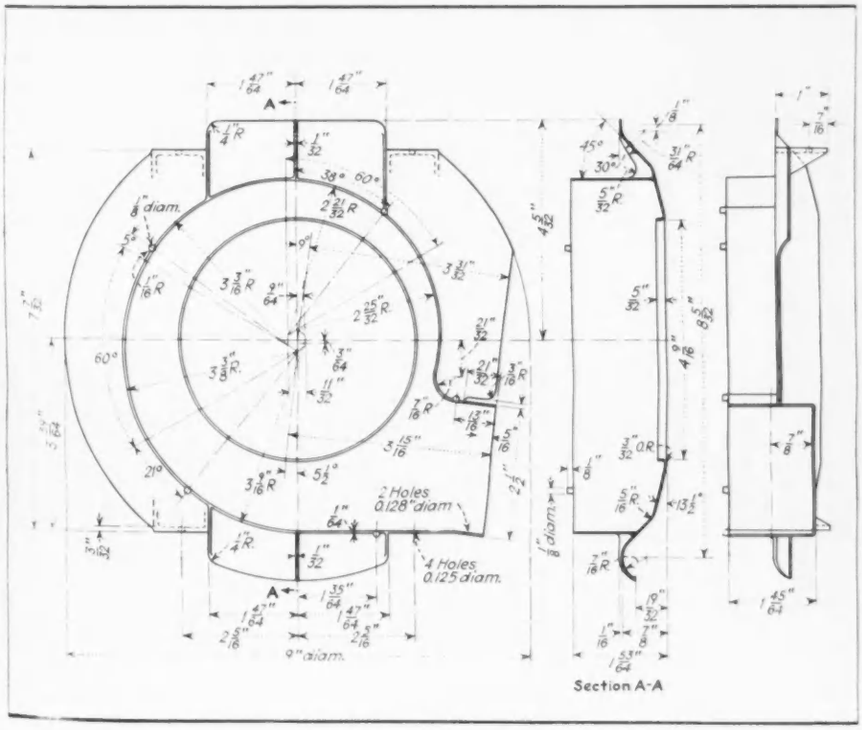


Cellophane hood is formed about bottle as elevator lifts it into spinner head. This action simultaneously releases clutch on the spinner head drive, revolving head and feeding tape.

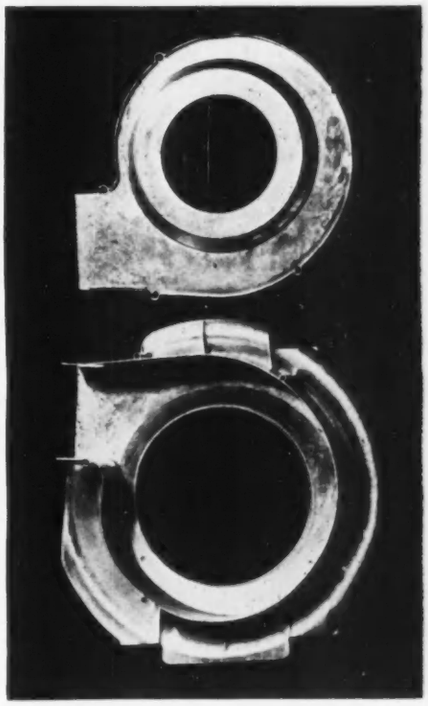


Center shaft does not revolve; can be raised or lowered to fit various bottle heights. Revolving outer column is chain-driven from a vari-speed transmission powered by ¾-hp. motor.

Wall Thickness 0.040 In.—Die Cast

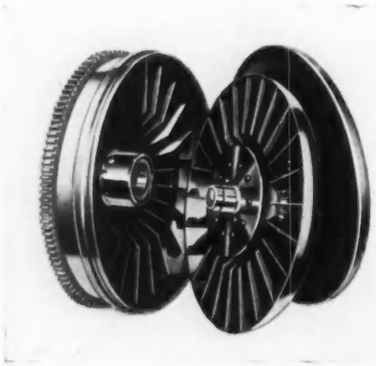


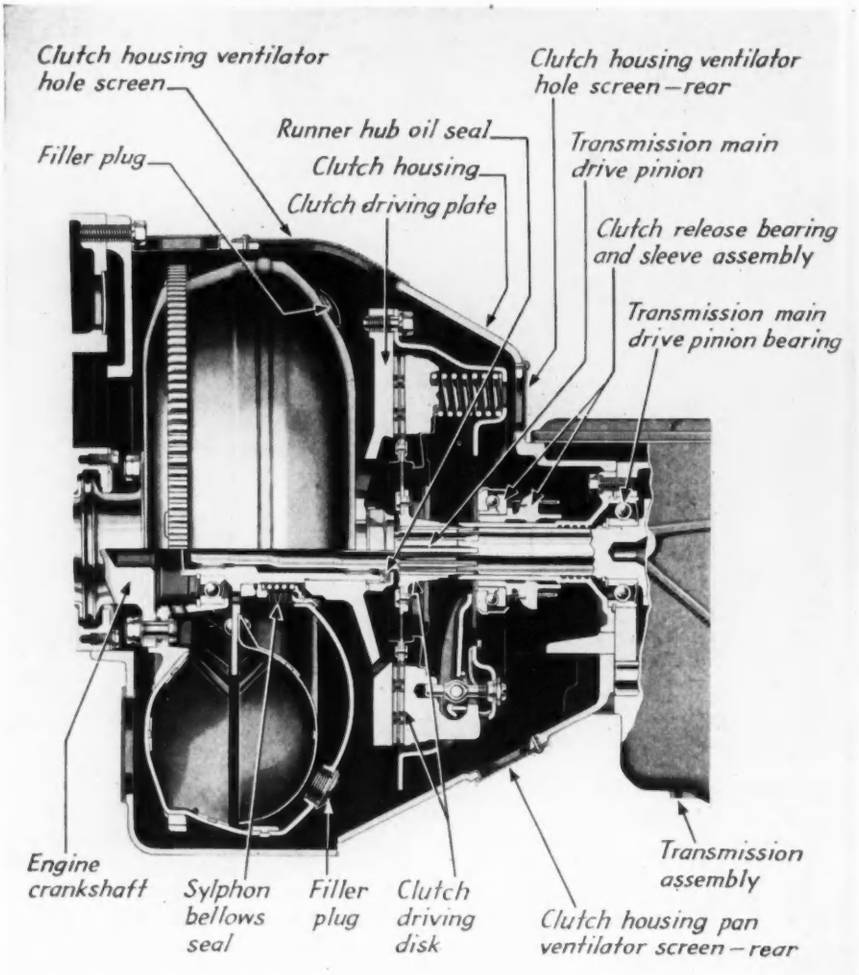
Practically as thin as if produced from sheet steel, this die cast blower housing, part of an automobile heater manufactured by E. A. Laboratories, has a wall thickness of 0.040 in. The zinc alloy die castings come from the dies accurately sized; no further machining operations being necessary.



Attachment of cover plate to main body is by means of drive screws. Drive screw holes are cored, not machined. Assembly of blower is rapid and easy. Body lugs are provided for mounting.

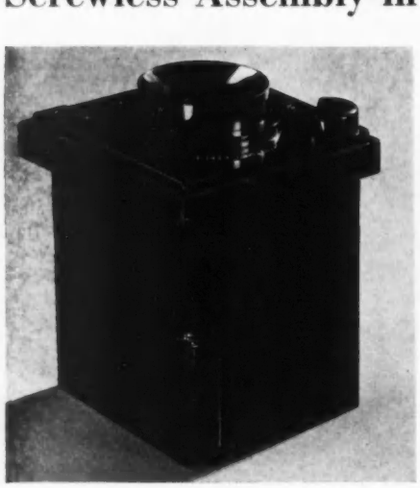
Modern Designs—Chrysler Imperial Fluid Coupling

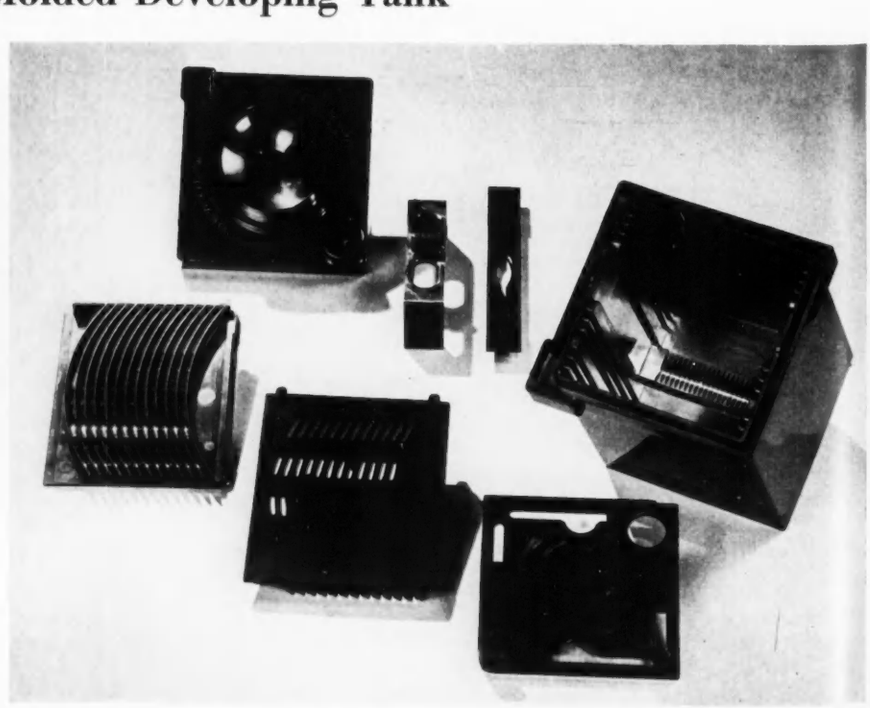




Chrysler fluid drive is based on an extension of the principle used in the English Daimler. It consists of a welded steel housing with a ring gear flywheel, 80 per cent filled with light viscosity oil, and containing two vaned wheels: the driver, attached to the crankshaft, and the runner which drives through the transmission to the rear wheels. In operation, the oil is thrown by centrifugal force from the driver vanes into the runner vanes, thus transmitting engine torque to the gear train. Slip is said to be low, about 1 per cent. It is claimed that all torsional vibrations are damped out. Major structural parts are of steel. Hubs for impeller housing and runner are forged, impeller housing, runner disk and cover are pressed from cold-rolled steel. Fins are stamped from cold-rolled steel and spot-welded in place in runner disk and impeller housing.

Screwless Assembly in Molded Developing Tank

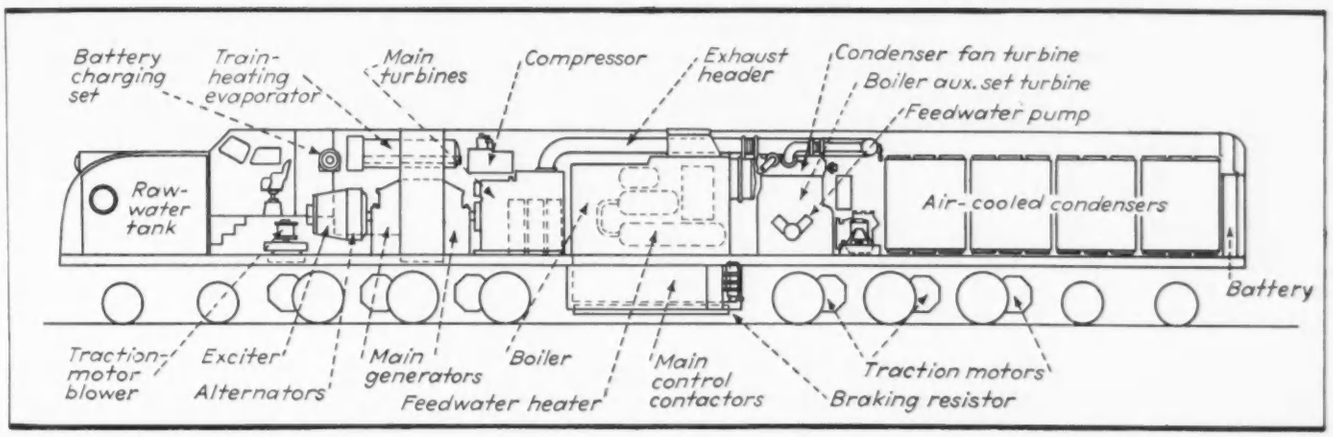




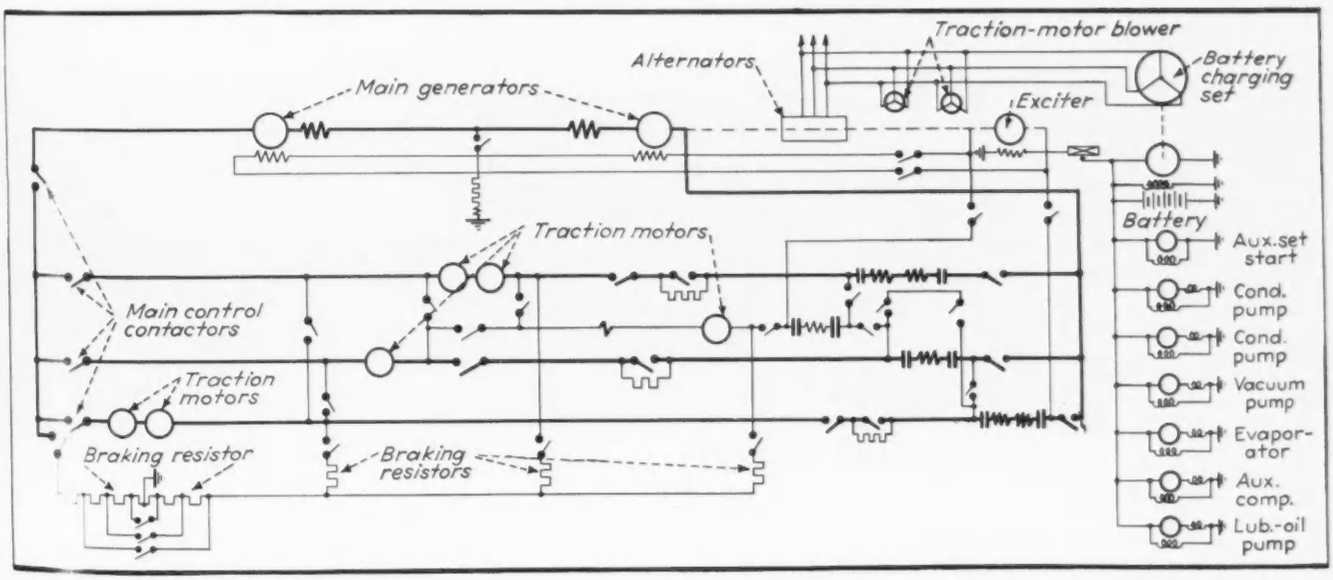
Seven close-fitting parts of chemical-resistant Bakelite phenolic make up this developing tank, adjustable for all sizes of film up to 4 by 5 in. By careful design study beforehand on a cellulose acetate model, and close checking of shrinkages and clearances, no mold changes were necessary.

Turbo-Electric Power Plant on Wheels

Basically a high-efficiency oil-fired steam plant with turbo-electric power generation, the new Union Pacific electric locomotive is the result of two years' development work and testing in the General Electric Erie works.

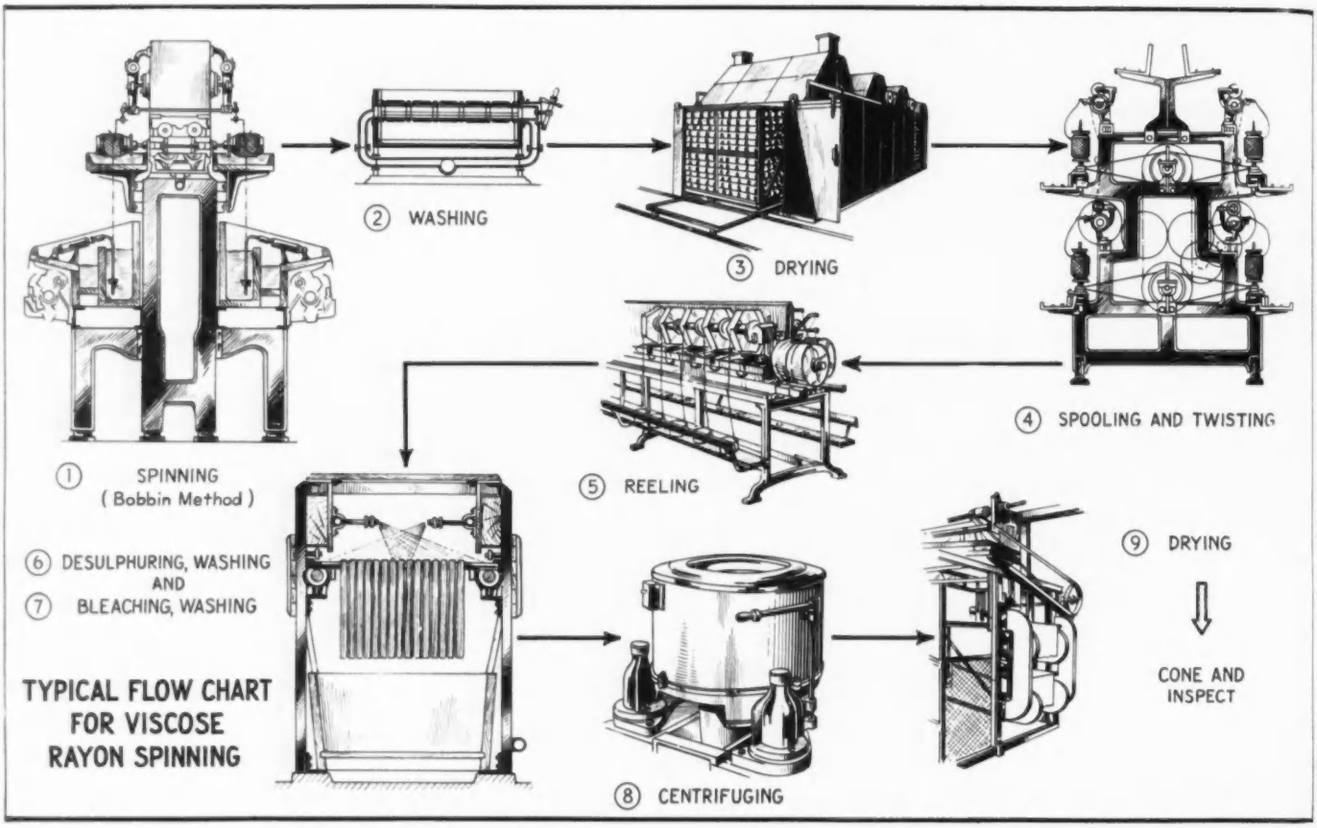


Limited space requirements necessitated extensive design research for the condensing equipment, which condenses and returns all steam used, permitting continuous runs of 500–700 miles. Turbine-driven fans supply forced ventilation to condenser tubes. A vacuum ejector extracts any small amounts of air which might leak into the closed system.



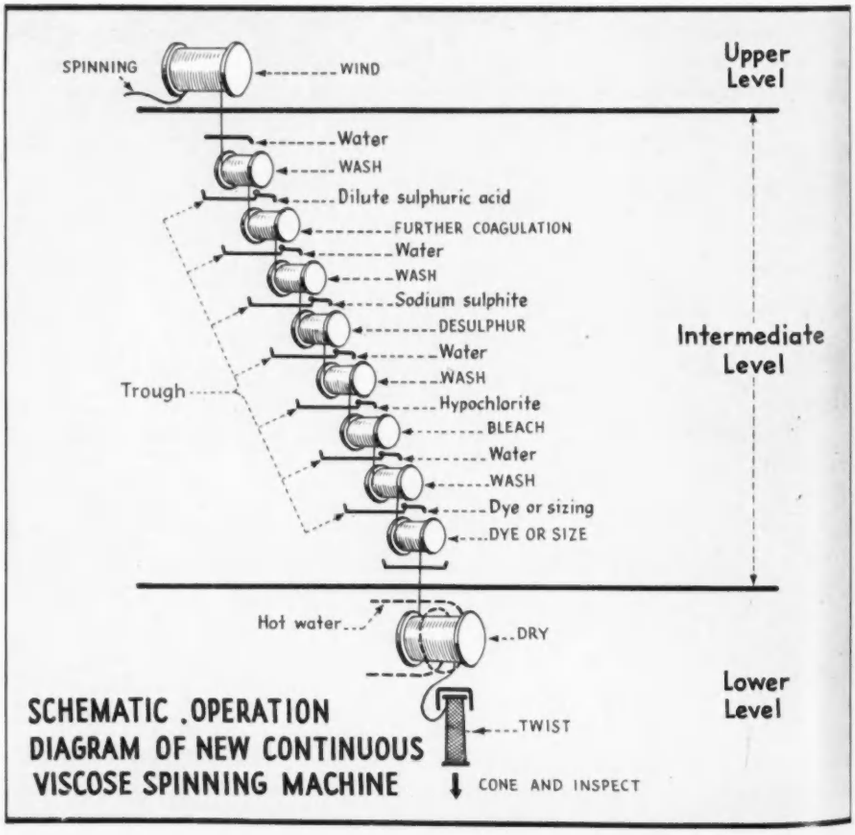
Complete automatic control of boiler auxiliaries and power units is provided. Speed is regulated by varying generator voltage across the axle-hung traction motors. Primary power for auxiliaries is supplied by an a.c. generator flexibly connected to the main generator shaft. Locomotive is braked by using traction motors as generators.

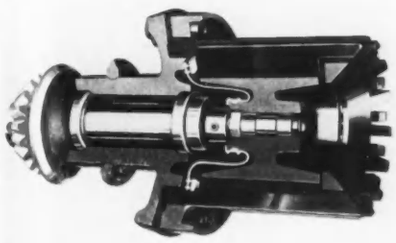
Machine That Spins, Processes, Dries and Twists Viscose Rayon Yarn Continuously



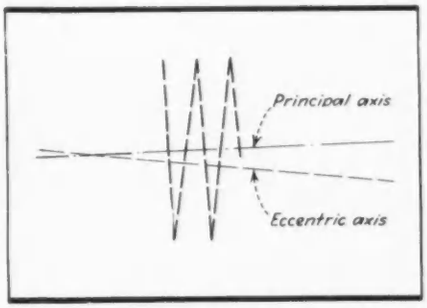
CONVENTIONAL methods of producing viscose rayon yarn (above) require, after the thread is spun, seven to eight unit operations performed on separate machines. Average processing time is 90 hr., plant investment is high, and product lacks uniformity in quality, since yarn processed in batches is subject to varying intensity of treatment, both chemical and physical.

Right—The idea that gave promise of making continuous processing possible, with each thread being treated individually and passing continuously over successive reels. The material embodiment of this idea presented many design problems. One was to cause automatic thread advancement on the reels; ingenious reel design solved this. Another problem was to find an economical material resistant to the corrosive treating chemicals. A special Durez phenolic resin was developed; the 36,400 reels required were molded by the Richardson Company to highly-necessary precision limits.

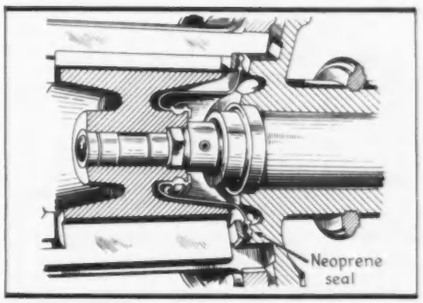




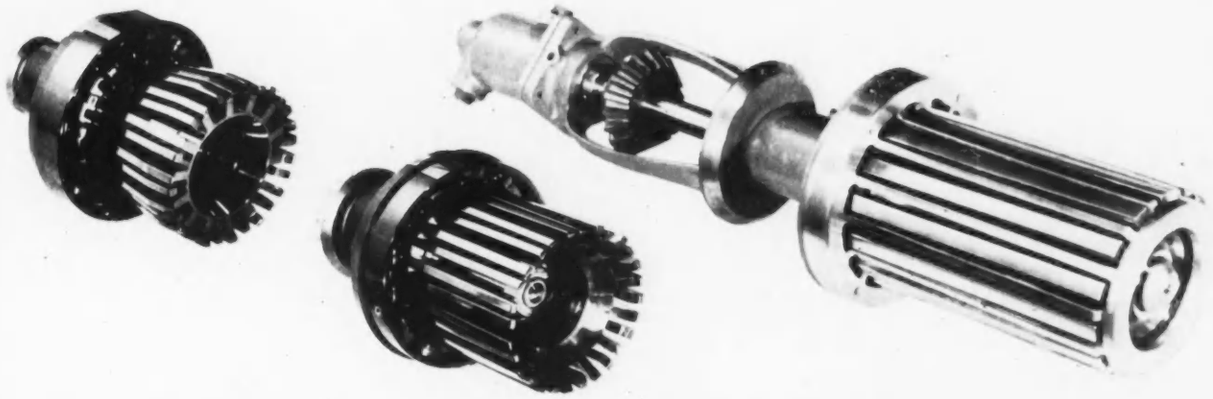
Reels are essentially two open-ended cages, set eccentrically one within the other with interlocking fingers and supported on a single shaft.



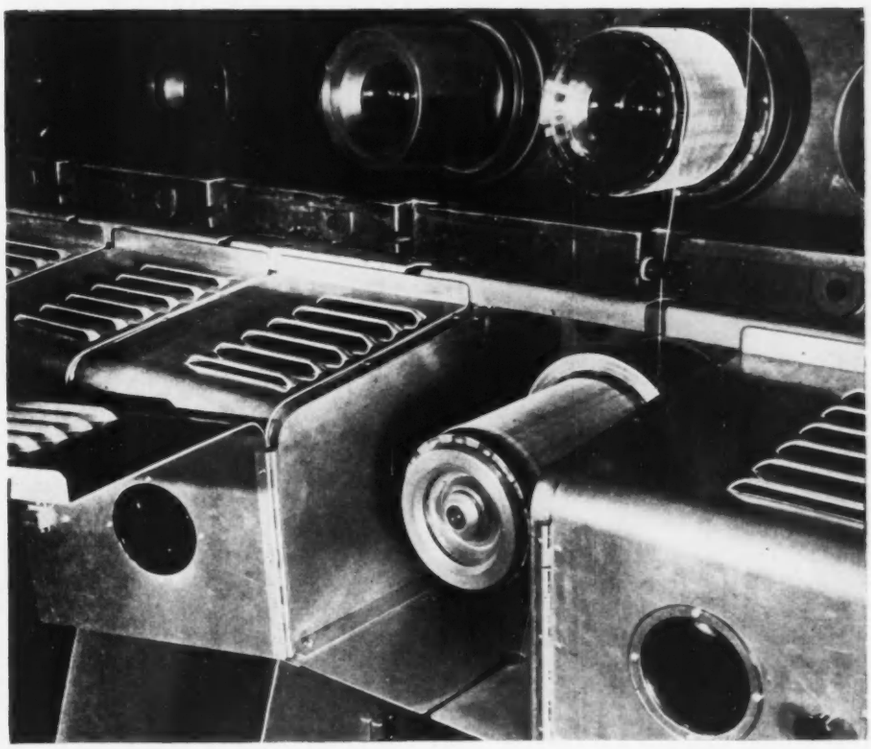
Diagrammatic view showing thread-leading method. Since cages do not rotate about the same center, relative motion of alternate fingers advances thread.



Neoprene seal protects individual reel shafts against the chemical and water treatment the continuously-advancing thread is subjected to at each step.



Spinning, processing and drying reels. Spinning reel, which winds the thread as it comes from the coagulating bath, is slightly flared at the discharge end; this stretches the thread as it passes over the reel. Shown at the center, the reel used in the eight intermediate steps is of constant diameter. Drying reel, shown at the right, is made of impact-extruded aluminum; it dries and feeds the yarn to a reciprocating twisting bobbin, fabricated of Insurok.



Each aluminum drying reel through which hot water circulates, runs inside a box-like housing to retain heat and control air currents. Located on the lower floor level, these reels are gear driven from a central drive shaft.

Continued on Next Page

Continuous Viscose Spinning Machine . . .

PRECISION in molding was required because any variation from exacting tolerances would affect the speed of thread travel and ultimate thread denier, as well as process control and yarn quality.

•

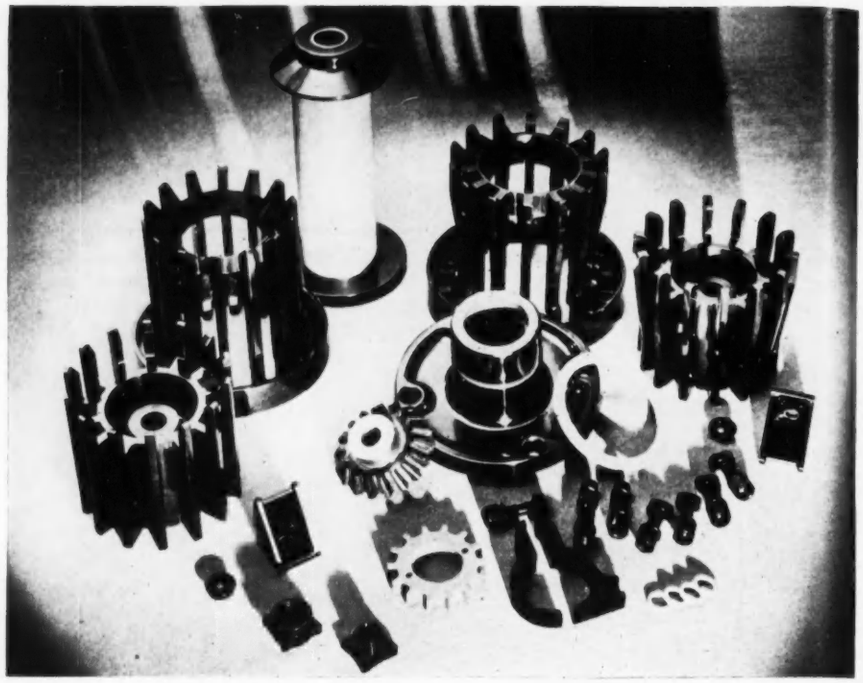
Industrial Rayon's $2,000,000 research and engineering development program created a machine that produces viscose rayon continuously, under exact process control.

•

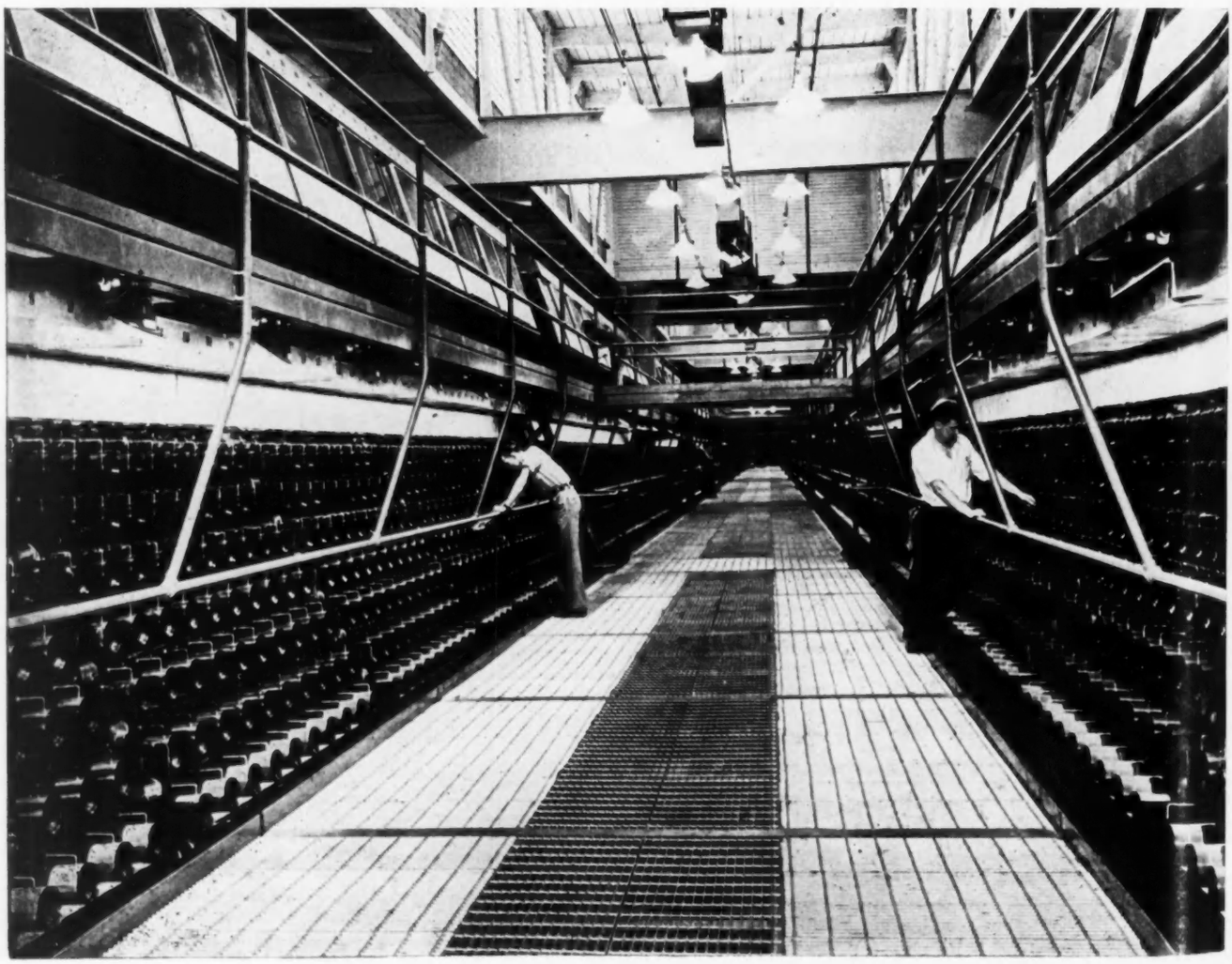
New rayon plant has 96,000 reels operating in a 3½-acre spinning room, a capacity of 12,000,000 lb. of viscose rayon per year, employs 1,000 people and represents an investment of $11,500,000.

•

Additional design details will be presented in a forthcoming number.



Plastic parts molded by the Richardson Company for this machine include jet unions, thread guide holders, brackets, seal rings, as well as reel cages.



ELECTRONIC DEVICES

For Detecting Variations in Dimensions and Color

G. C. DEVOL, JR.
Vice-President, United Cinephone Corporation

Scanning systems and electronic circuits are described which are designed to detect in products dimensional variations from standard and to inspect surfaces for variations in color

PHOTO-ELECTRIC and electronic controls designed for inspecting, grading and classifying various products are no longer a novelty in many diversified industries. In the detection of unlabeled boxes, cans, packages and cards, photo-electric controls have increased the speed of production, have proven to be more accurate and also more economical than methods which are dependent upon the human eye.

It is relatively simple to register, for inspection by photo-cell scanning units, items such as cans, packages, bottles and pieces of mail which are usually handled on some type of conveyor.

Detection of missing labels or labels out of alignment, that are of a color different than the body of the article, is accomplished with reflected light scanners placed on the side of the conveyor parallel to the article being inspected. Normally scanning is done while the articles are in motion.

Sometimes where two sides are to be inspected at once, stop motion movements are employed to gain time necessary for inspection. The photo-control amplifier is adjusted by biasing the light source so as not to operate on the body of the article. As this beam is interrupted it places the secondary beam in operation. The latter scans the side of the box and operates if there is a label on the box. If the label is missing the control will not operate and the interlocking relay will therefore stay in a closed position. This relay in turn is used to operate a removing device such as a solenoid or a compressed air kick-off mechanism.

A standard multiple-tube amplifier type of photo control is used when inspecting colored articles such as beans, oranges, peas, tile and pottery. When there is a great difference in shade between good beans, which are normally white, and poor beans, which may be an off shade of brown, the latter are rejected. The control operates whenever a dark bean is presented to the eye.

Where there is but a slight difference between two shades of blue it is a more difficult matter to separate the articles, and efficient apparatus involves the use of a very sensitive balanced circuit for the photo-electric controls and also necessitates precision scanning units equipped with split prisms and tri-colored filters. To obtain the greatest passage of light of the particular color being inspected it is sometimes necessary to use revolving scanning disks similar to those used in television. This allows a small dot of high intensity light to intermittently scan a small area.

This system can be used to inspect large areas such as automobile panels

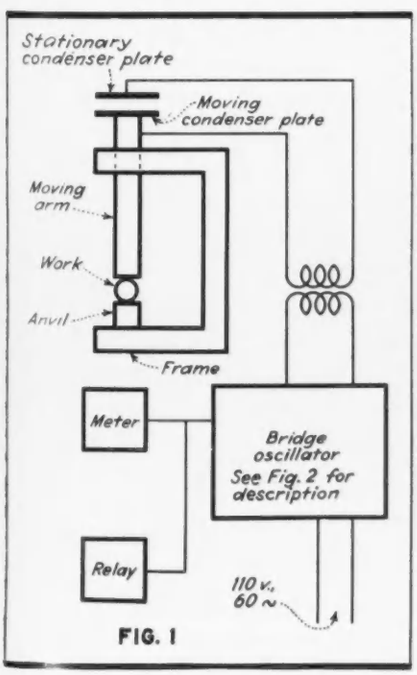


Fig. 1—Parts and circuit of a micrometer in which a variable capacity or condenser effect is employed with a bridge oscillator, a relay and a meter to indicate the variation of a dimension from a standard

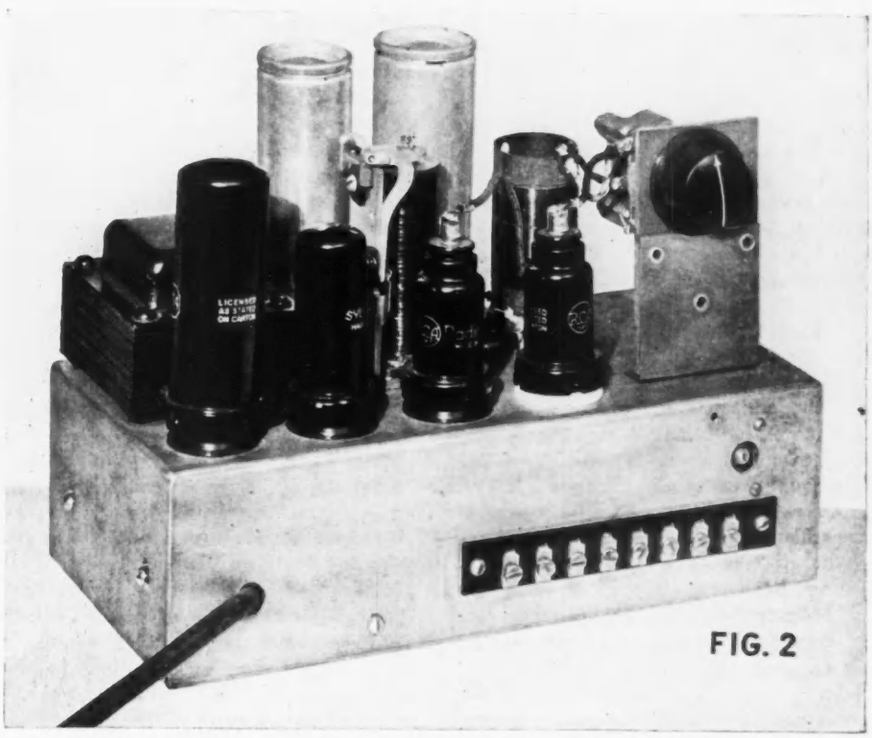


Fig. 2—Bridge oscillator used with capacity micrometer shown in Fig. 1. As condenser plates approach each other they decrease the capacity which unbalances the oscillatory circuit, this allows current to flow in the final amplifier which in turn closes relay

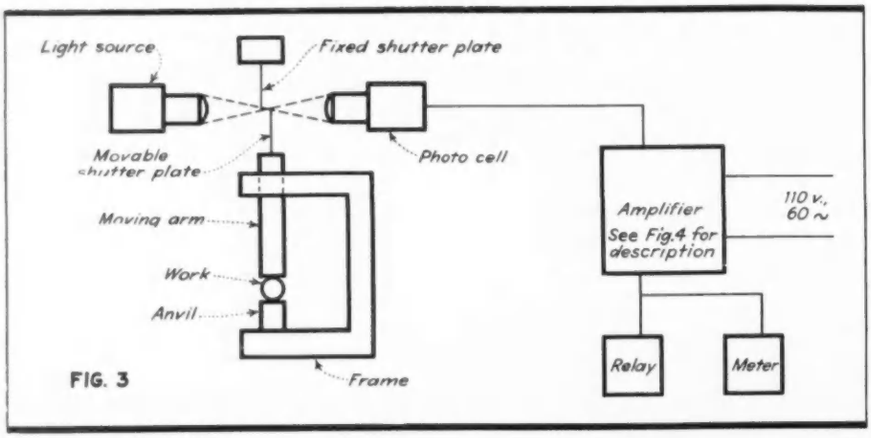


FIG. 3

Fig. 3—Light valve micrometer in which the amount of light that passes between a fixed and a movable shutter to a photo-cell is used with an amplifier, a relay and a meter to indicate variation from a dimensional standard

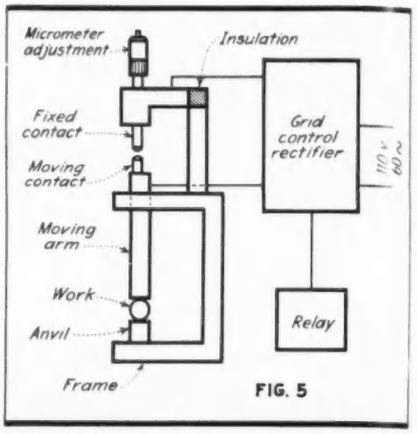


FIG. 5

Fig. 4—Light proportioning amplifier used with light valve micrometer shown in Fig. 3. This amplifier operates on small variations of the light relayed through the shutters, it can be set to detect extremely small changes in the volume of light received on the photo-cell scanner

Fig. 5—Screw micrometer with barrel and a spindle mounted on a fixed support, the anvil is carried on a movable arm, when the anvil touches the spindle a circuit is closed which operates the grid control rectifier which then energizes the relay

FIG. 4

and refrigerator cases. There is one drawback, however, to this type of inspection. Although a thyratron type of photo control can be operated at high speeds the length of time required to scan an area a foot square is approximately from ½ to 1 minute, depending on the speed and number of holes in the scanning disk. This system can, therefore, be used economically only for products which require a high degree of accuracy in inspection, such as woven cloth, fabric, phenolics and synthetic plastics.

Most color inspection systems work on the principle of neutralizing three photo-cells, one of which inspects the standard sample, and the other two inspect the surface in question. A small prism is used to split a single beam of light into two equal parts so that the light reflected from each article is exactly the same regardless of voltage fluctuations at the input of photo-cell control and light source. Each photo-cell is connected to a bridge amplifier which is adjusted so that it will cancel out when the light is equal on all photo-cells.

In the chemical and distilling industries, such as the manufacture of dyes, whiskeys, paints and gasoline, it is often necessary to maintain a definite standard of density or color. Sometimes the coloring has a definite bearing on the chemical solution. Since many chemical solutions are transparent, transmitted light may be used, and in many systems the output of the photo control is connected to various types of escapement movements, automatic proportioning controls and regulators. In this type of control it is seldom necessary to use complicated optical systems like those used in measuring reflected color.

Proportioning System

One control system which is used for coloring blended whiskeys is operated by passing two liquids through separate glass pipes which discharge into a constantly agitated blending chamber. Between the glass pipes and the mixing chamber are two proportioning controls. A pipette is attached to the side of the blending chamber to permit the continuous drawing of samples of the liquid. Two photo-cells scan the samples, one is connected to the color proportioning control, the other is connected to the white distillate proportioning control. As more or less coloring matter or distillate is needed in proportion to the mixture, one control operates on a minimum value of light transmitted, and the other operates on a maximum of transmitted light. Interlocked with these two controls is a master standardizing control which is set to the degree of color necessary when both proportioning controls are at a mean level. The proportioning controls are so arranged that a normally closed relay contact of one will be held open and the normally open contact of the other will be closed at the same instant. These contacts are wired in series with the master control. The system is then in a balanced condition.

In classifying and grading for size, where a tolerance of one ten thousandth of an inch is sometimes required, various systems are used. Four inspection units which are designed to be included in complete inspection machines will be described.

In the capacity micrometer shown schematically in Fig. 1, one plate is attached to the main body of the micrometer and the other plate to the moving arm. These plates are all connected to a balanced oscillator which in turn operates a relay or rejecting device and a meter, for indicating variation from standard, which is calibrated in tenths of a thousandth of an inch.

A light valve micrometer is shown schematically in Fig. 3, that operates on

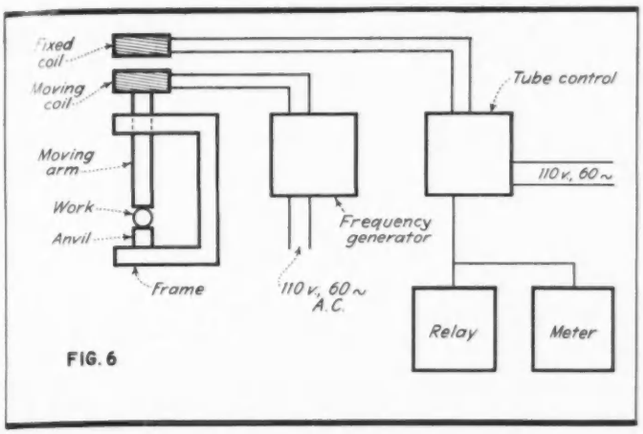


FIG. 6

Fig. 6—Induction micrometer which uses two coils which move in planes parallel to each other. The amount of alternating current induced in the fixed coil varies more or less in proportion to the distance between the coils. A tube control, a relay and a meter are in circuit with the fixed coil

Fig. 7—System for automatic inspection of variations in the color of a surface consisting of a scanning disk, light source, filter unit, condenser and differential lenses, with a bridge amplifier

Fig. 8—Differential bridge control, which includes timing amplifier in system shown in Fig. 7, receives currents generated by scanning cells through bridge circuit which in turn are amplified and passed on to relay circuit, it also receives impulses through timing cell which blocks the operation of the scanning cells on the dark periods of no light generated by scanner. It also receives through bridge circuit the output of standardizing cell which normally balances bridge circuit

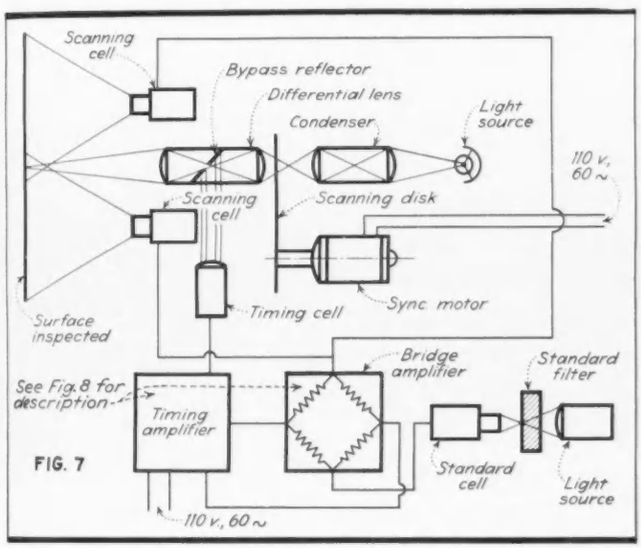


FIG. 7

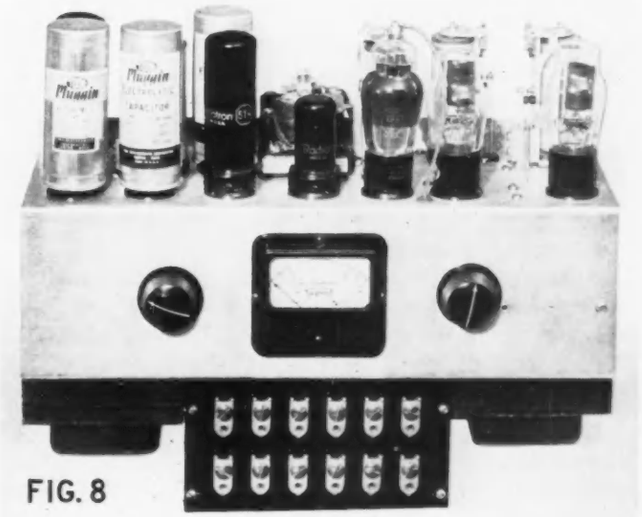


FIG. 8

a variable degree of light which the valve passes to the photo-cell. This system is quite accurate since it adds no mass to the gaging rod of the micrometer.

The contact micrometer shown in Fig. 5 has two contacts. One is attached to the movable arm, the other is solidly mounted. Automobile manufacturers are among those who use this type for rapid sorting, to separate parts having variations of one ten thousandth of an inch on some critical dimension for parts such as valve lifts, camshafts, wrist-pins and bearings. These micrometers are used in a series of steps grading up from the maximum to the minimum tolerance.

Color Inspection System

The induction micrometer shown in Fig. 6 uses two torridoral coils which move in parallel planes with respect to each other thereby allowing more or less alternating current to flow from one to the other. These coils are in turn connected to a grid rectifier tube which then operates the relaying.

The system shown in Fig. 7 is used for automatic inspection of color. For purposes of description it will be assumed to cover an inspection operation to determine any variations in color of a surface.

The scanning disk cuts or interrupts a beam of light from light source which in turn is relayed to condenser lenses and then by the differential lens on to the surface of the article being inspected. The entire surface of the article to be inspected is rapidly and completely covered by a series of successive dots of light emanating from the differential lens through the scanning disk. If any portion of the surface being inspected has any defects, in other words is off standard, the photo-cells will receive through reflected light a different intensity of light than the bridge amplifier which has been balanced by means of the standard cell. Photocells are connected in parallel to one arm of the bridge amplifier. The standardizing photo-cell which is connected to the opposing arm of the bridge amplifier receives a given amount of light from the filter unit through which it is transmitted.

Obviously under this system it is necessary to first determine the standard against which the inspection is to be made which is done by pre-setting the filter unit to the required standard for the product. In the passage of dots of light to the surface under inspection, through the scanning disk, notwithstanding the speed at which the disk operates, there is a period of no light which is equal to the period of dots of light. Naturally, the sensitive bridge amplifier would register every interruption of beam, just as it would in detecting any off color; however, the timing photo-cell blocks off the photo-cells so that when no light is passing through scanning disk to the surface being inspected, the amplifier will not function. The functioning of the timing photo-cell serves to eliminate any neutral or no light periods which narrows the basic function of the photo-cells to the determination of any shade of color as opposed to the standard set by the filter unit. Immediately upon an off color being detected on the object being inspected by the photo-cells the bridge amplifier becomes unbalanced causing the relay which is connected with a ram or solenoid to push the defective object off the conveyor as rejected.

To inspect a given area of surface the number of photo-cells necessary is in proportion to the extent of the area. It has been assumed in this description that two photo-cells are sufficient.

The real purpose of the use of photo-cell units, otherwise termed scanners, is to register any variation in the reflected light thrown back from the surface that is being inspected.

HIGH-TEMPERATURE DESIGN

Data Required and How It Is Obtained

E. A. DAVIS
Research Engineer, Westinghouse Electric & Mfg. Company

IN THE DESIGN of members for high temperature service, the governing factor is the allowable total deformation in a given time. This limiting amount of strain will vary with the application. For example, in certain furnace or boiler parts it may be perfectly safe to set the limit at two or three per cent strain in ten years while for moving parts in high temperature machines it may be necessary to keep the strain less than one-tenth per cent in ten years. The total deformation is made up of elastic deformation which is proportional to the stress and plastic deformation which increases in some manner with time. It is this gradual increase in the plastic or permanent strain under prolonged stressing which has acquired the name of "creep."

The amount that any member will deform or creep in a definite period of time will depend upon the stress and the temperature to which it is subjected. It will also depend to a large degree upon the material used. Furthermore, two materials which have quite similar physical properties at room temperature may differ greatly in creep properties at elevated temperatures. For these reasons it is not possible to prescribe a set of permissible stresses which could be used for random materials. In order to make a reasonable design of a member for high temperature service it is necessary to have test data on the actual material to be used. Because of this, designers of high temperature equipment are forced to spend a large amount of time and money on some kind of a testing program.

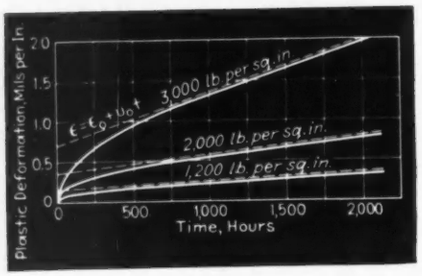


Fig. 1—Typical creep curves. The first portion of each curve is rounded, because of the strain-hardening, after which the curve becomes a straight line

In general, tests by means of which design data are secured are conducted in such a way as to duplicate as nearly as possible the actual conditions under which the material is to be used. Results from these tests are then interpreted and extrapolated to furnish direct design information. Other tests based on more idealistic conditions are also made in order to study the fundamental laws which govern the deformation of metals. Comparatively little is known about these fundamental laws at present but when they are better understood it may be possible to predict creep behavior with less test information than is now necessary.

Of the tests which attempt to duplicate service conditions, the long time creep test is the most significant. From this test design information is obtained which can be used for determining permissible stresses in members that are subjected to fairly constant loads, for in the creep test a bar is kept under a constant load and at a prescribed temperature for a period of at least three months. Some creep investigators, however, have in a few cases allowed the bars to remain under load for periods up to five years. At regular intervals during the test the deformation or creep is measured and is usually plotted as a function of time, as shown in Fig. 1. The Westinghouse equipment for making this type of test was described in a recent issue of this magazine. (*Product Engineering*, July 1938, p. 269)

Interpreting Creep Curves

A study of the set of curves shown in Fig. 1 will reveal several characteristics which are common to most high temperature materials. The first portion of any of the curves is quite rounded which shows that the material becomes stronger as it deforms. This phenomenon is referred to generally as strain-hardening. The curves later tend to become straight and the material loses its ability to strengthen as a result of additional strain. It was found in the extremely long tests already mentioned that the curves for low stresses become straight and stayed straight for the duration of the test. This straightening of the curves is probably due to some influence of the temperature and the time, since it is well known that the properties of many materials change with time. If this change takes place in such a way as to make the material stronger it is termed age-hardening. If the change is such that the material weakens it is known as softening or annealing. Whenever a material is held at temperatures considerably below the normal softening range it is possible that annealing takes place at a very slow rate. If this slow annealing would progress just fast enough to offset the strengthening effect of the strain-hardening, the material should strain at a constant rate and the creep curves should become straight lines as has been observed.

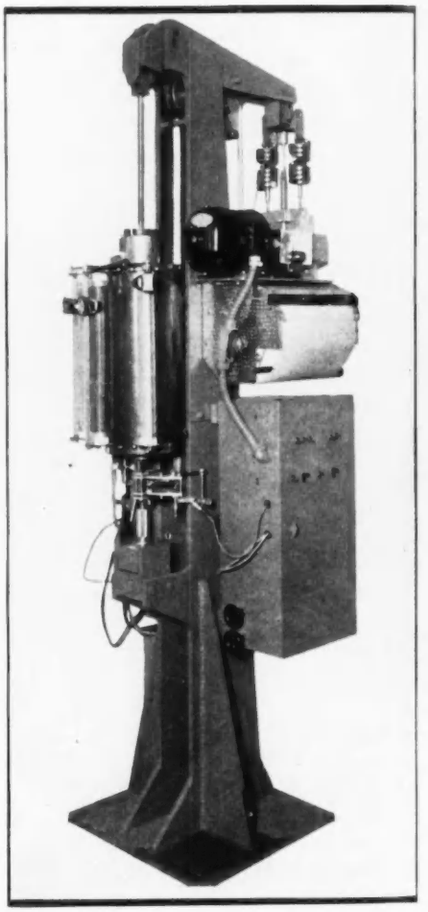


Fig. 2—A relaxation testing machine which automatically decreases the load on the test bar so as to keep the length of the stressed portion constant

The fact that creep curves become straight and remain straight for a short period of time is no guarantee that they will remain straight for periods corresponding to the service life of a piece of high temperature equipment. Nevertheless, creep curves must be extrapolated to periods of several years and probably the best and simplest assumption to make is that at low stresses the

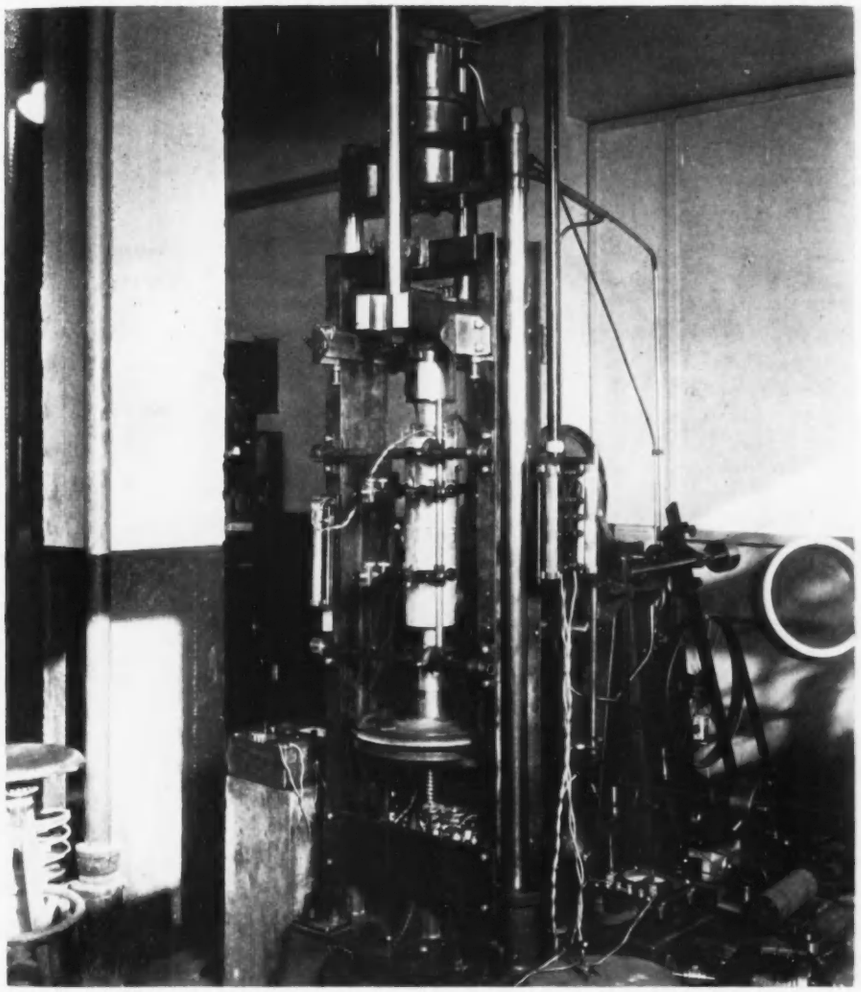


Fig. 3—A constant strain-rate machine which automatically loads the specimen so as to strain it at a constant rate

creep curves remain straight for the required period of time. It must be borne in mind, however, that this is only an assumption. The only way to determine whether or not a creep curve would be straight for twenty years is to carry out the test for that length of time.

In order to furnish information for parts stressed in bending, a test has been devised in which a bar in pure bending is kept under a constant moment. The deflection is measured and plotted as a function of time just as in the long time creep test. These curves have much the same shape as the long time creep curves and are used in the same manner.

Another test which aims to duplicate service conditions is the relaxation test for bolting materials. See the paper "Relaxation of Steels at Elevated Temperatures" by A. Nadai and J. Boyd, Fifth International Congress of Applied Mechanics, Cambridge, Mass., 1938. In practice, when a bolt is drawn up tight on rigid flanges it is found that the load on, or pull exerted by, the bolt drops with time and eventually the bolt becomes loose. If the flanges can be considered as perfectly rigid the deformed length of the bolt remains constant and any increase in the plastic strain due to the stress must be accompanied by a decrease in the elastic strain. The stress, of course, decreases in the same proportion as the elastic strain. Fig. 2 shows a photograph of a machine in which relaxation tests are made. The machine automatically decreases the load on a test bar in such a manner that the stressed length remains constant. The drop in stress as a function of time is recorded on a chart. From the results of this type of test it is possible to determine what initial stress must be put on a bolt in order that the stress will not drop below a certain minimum value in a given time.

Some high temperature parts such as rotating shafts are subject to rapidly fluctuating loads and this makes it important to investigate the behavior of materials under fatigue conditions at high temperature. There has not been a great amount of work done in this field, but the need for such information exists and tests of this nature will become more common in the future. When some materials are heated they become more ductile while others become embrittled at high temperatures. For this reason the fatigue properties at normal temperatures may not be a safe guide in predicting high temperature results.

Determining Aging Characteristics

The constant strain rate test is a test which deals chiefly with the fundamental relations existing between the stress, the plastic strain and the plastic strain rate. See the paper, "Constant Strain Rate Tests on .35 Carbon Steel K-20 at 850° F.," by A. Nadai and E. A. Davis, *Transactions*, A.S.M.E., Vol. 59, p. 447, July, 1937. In this test, which is carried out on such a machine as shown in Fig. 3, a bar is pulled at a uniform rate of stretching. Then another bar is tested at a different uniform rate. Thus a family of stress-strain diagrams for various constant strain rates is obtained. From these results it is possible to study the effect of the rate of strain upon the yield stress. A family of these curves for an ordinary carbon steel at 850 deg. F. is shown in Fig. 4. An idea of how metals react to the speed of deformation can be gained from this set of curves. For most steels at temperatures near 500 deg. C. it is found that in a certain range the stresses corresponding to a given amount of strain vary as the logarithm of the

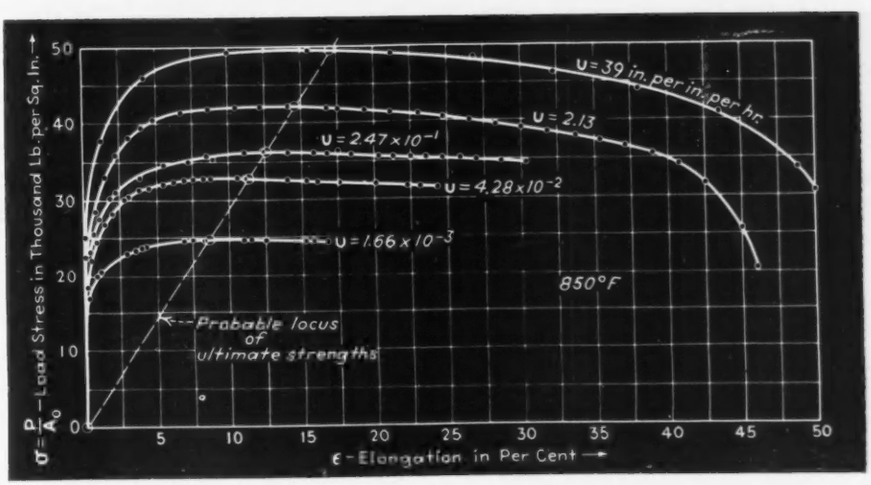


Fig. 4 Stress-strain diagrams plotted from the results of constant strain-rate tests

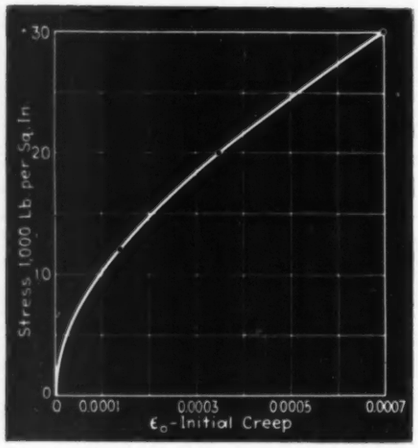


Fig. 5—Curve of stress versus initial creep

creep rate. This is especially true at values of plastic strain greater than one percent.

Occasionally material is tested to study the change in the strength of the material with time. These tests are usually called aging tests. The aging characteristics are determined by measuring at frequent intervals the hardness of a bar that is kept in a furnace at the prescribed temperature. Another method is to place several test specimens in a furnace which is held at a constant temperature. Specimens are removed after definite intervals and tested in short time tension tests. In this way a history of the physical properties of the material over a given period of time is obtained. In one case the writer tested the hardness of a twelve percent chromium steel at 850 deg. F. and found that the material continuously hardened over a period of one year. The Brinell hardness increased from 210 at the beginning to a value of 230 at the end of the period. Just how long the material would have continued to harden is not known but it is generally found that materials which harden at first will afterwards start to soften. The time required for each process depends greatly upon the temperature and the composition of the metal.

Selecting Design Stresses

In the foregoing paragraphs various types of tests have been described in order to convey to the reader an idea of the methods by which high temperature design information is obtained. The designer is particularly interested in how this information may be used. Obviously creep tests cannot be run at stresses so low that the total amount of creep would be comparable with that allowed in service. Neither can the tests be carried out for the full service time. For this reason it is necessary to extrapolate creep test results obtained at fairly high stresses to regions of much lower stress and to greater times.

Whenever test data is extrapolated it is necessary to make certain assumptions. As has already been mentioned the creep curves for low stresses can be assumed to be straight lines for large values of the time t. The creep curve can then be expressed as

$$\varepsilon = \varepsilon_o + \mu_o t$$

where ε is the plastic strain and μ_o is the minimum creep rate. This expression was introduced by P. G. McVetty in a discussion on the interpretation of creep tests. See his paper, "Working Stresses for High Temperature Service." *Mechanical Engineering*, March, 1934. The strain represented by ε_o is sometimes referred to as the "initial creep." The term minimum creep rate for μ_o is used in a proper sense, for at higher stresses the creep rate decreases to this value and later it starts to increase due to necking of the bar.

The constants ε_o and μ_o both depend upon the stress and the extrapolation of creep data consists of finding the relations between these two quantities and the stress. If the creep represented by ε_o is very small compared to that represented by the term $\mu_o t$ it may be neglected entirely. If not, the values of ε are usually plotted against the stress and a smooth curve drawn through the

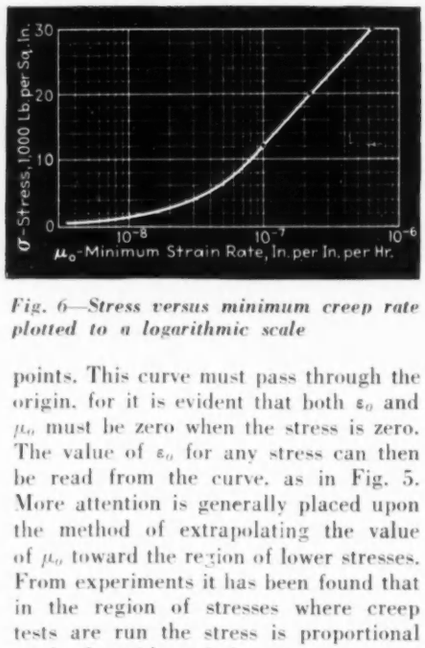


Fig. 6—Stress versus minimum creep rate plotted to a logarithmic scale

points. This curve must pass through the origin, for it is evident that both ε_o and μ_o must be zero when the stress is zero. The value of ε_o for any stress can then be read from the curve, as in Fig. 5. More attention is generally placed upon the method of extrapolating the value of μ_o toward the region of lower stresses. From experiments it has been found that in the region of stresses where creep tests are run the stress is proportional to the logarithm of the minimum creep rate μ_o. Unfortunately the logarithmic curve does not pass through the origin and the extrapolated curve for stress versus minimum creep rate has to be modified somewhat in order that the creep rate be zero when the stress is zero.

Extrapolating Data

One means of extrapolation which may be used is given by the expression:

$$\sigma = \sigma_o\left(1 + \ln \frac{\mu_o}{\mu_1}\right)$$

where σ is the stress and σ_o and μ_1 are constants. This is applicable for creep rates greater than μ_1. For rates below μ_1 the expression

$$\sigma = \sigma_o \frac{\mu_o}{\mu_1}$$

is used. This method of extrapolation was suggested by A. Nadai of the Westinghouse Research Laboratories. Fig. 6 shows a plot of stress versus minimum creep rate. In this plot the above equations were used in determining the shape of the curve. The total deformation can now be computed for any stress.

Calculating Deformation

Elastic deformation can be calculated from the elastic formula, the amount represented by ε_o can be taken from the curve σ versus ε_o (Fig. 5) and the amount represented by $\mu_o t$ can be calculated from the values given in Fig. 6. If the sum of these three terms is a larger amount than the allowable total deformation, a smaller stress will have to be chosen. The stress chosen by this method will not contain any factor of safety. It will probably be desirable to apply a safety factor to this stress to take care of such things as slightly defective materials, stress concentrations, and possible overheatings.

It must be pointed out again that it is practically necessary to have test data on the same material as is used in the design. Very little creep test data are to be found in the literature. The most comprehensive list is probably the pamphlet published in February, 1936, by the A.S.T.M. Committee A1 on steel. This booklet is entitled "Data on Nominal Creep Strength of Steels at Elevated Temperatures" and contains creep test data on several steels. The chemical composition of the steels and in some cases the heat treatment are also given. In addition there is a discussion on the general subject of creep tests. Other test results are given in various publications but they are too scattered to be listed here.

Sources for Creep Data

The importance of using a great amount of precaution in selecting a working stress for high temperature members cannot be over emphasized. The strength of the material depends upon several variables and an understanding of these factors which influence the behavior of metals is something to be greatly desired. Knowledge of these foundamental laws is gradually being developed, but in the meantime designers must establish safe working stresses. It has been the object of this paper to point out some of the means by which such stresses are determined at the present time.

PLASTICS OVER METAL

Why and How to Design Metal-Backed Plastics Parts

C. H. WHITLOCK
Firestone Tire & Rubber Company

A new process that is finding rapidly increasing use for parts that require the strength and rigidity of steel plus the highly desired characteristics of plastics

DURING the past two years the use of cellulose acetate molded parts increased at a greater rate than perhaps any of the other synthetic molding materials. This has been attributed to several factors. Such parts are easy to fabricate, the material being thermo-plastic and tough. Another advantage is that the material is obtainable in almost any color, and because appearance is becoming a steadily more important consideration in the design of products, this color advantage has been a strong factor contributing to the increasing use of cellulose acetate molded parts.

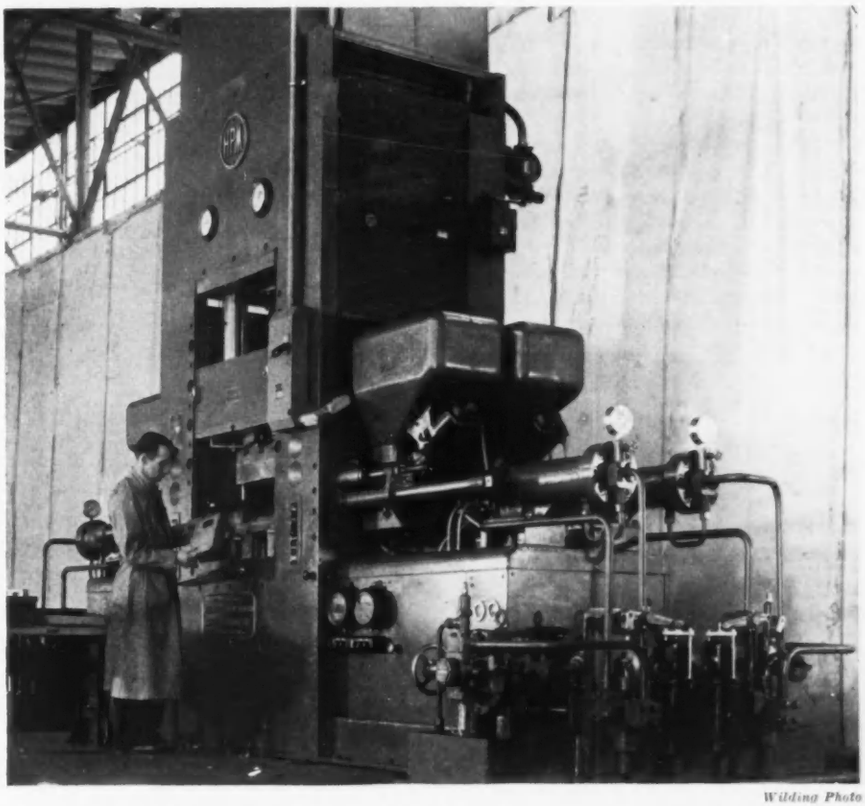
However, like every material, cellulose acetate has its limitations. Although it was found highly satisfactory for small parts, when its use was extended to larger pieces it was found that its flexural strength, shrinkage with age, and warpage because of its extreme sensitivity to atmospheric conditions, presented some difficult design problems. In some instances the flexibility and warpage difficulties encountered in large pieces were overcome by rigidly fastening the part to metal, as was done successfully in some large pieces used in the automotive field. But such designs did not satisfactorily solve the problem of eliminating the inherent difficulties in large cellulose acetate molded parts. It was evident that a radically new type of design of the parts would have to be developed. The molding of acetate over metal appeared to promise logical solution.

In the design of the instrument panel and glove compartment door of the 1939 Chrysler, each piece about 16 in. by 7 in., the parts were first designed for acetate molding without any metal backing. An experimental mold was built for the glove compartment door and sample doors were made. They lacked rigidity, even though the section was $\frac{1}{8}$ in. thick. It was then decided to design the door to be stamped out of light gage metal and cover it with a thin coating of acetate material. Such a design would not only reduce cost but would also solve the problem of warpage and shrinkage. This was done. (See P.E., p. 63, Feb. '39)

At first thought it might seem that it would be much cheaper to simply enamel a metal stamping and not go to the bother and cost of molding an acetate coating over the metal. However, there are a number of specific cost factors involved in the enameling process, the greatest one being the cost of conditioning the surface of the metal stamping preparatory to applying the enamel finish. All irregularities in the surface, such as marks from spot welding, must be dressed down, otherwise they will show on the finished surface. And furthermore, an enamel finish would not possess the inherent durability of a molded-on cellulose coating nor would it have other advantages such as noise deadening, translucence, depth of color, softness and warmth to the touch and similar qualities that are not obtained in an enamel-finished metallic surface.

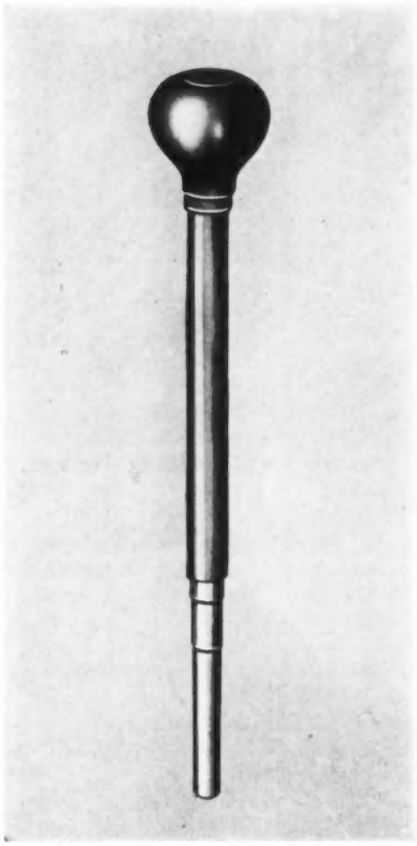
In the development of the process of molding acetate over metal, a number of manufacturing and design problems had to be solved. The metal stampings must be lacquered or painted with a single coat to give a uniform color over the entire surface of the stamping. Otherwise unpainted burn marks left by spot welds would show through the translucent acetate. Also, it is necessary to have the acetate coating of uniform thickness, because a section of varying thickness would show shadows when light shades or extremely translucent acetate coatings are applied.

One major problem in developing the



Wilding Photo

Stamped panels being coated two-at-a-time with cellulose acetate on a 500-ton, 4-nozzle injection molding machine at the Firestone plant, at the rate of two per minute



Acetate covered one-piece gear shift lever and knob. The metal core is a simple forging which requires no cleaning or polishing prior to the application of the acetate covering

process of molding acetate over metal was caused by the fact that there is normally little or no adhesion between cellulose acetate and metal. Consequently, means for mechanically anchoring the acetate must be provided. Sometimes this can be done by extending the acetate coating down over and under the edges, as was done in the panels for the Chrysler car. But ordinarily this will cause breaking away of the acetate material when the pieces are being removed from the mold unless the heating of the material before injection into the mold cavity has been controlled properly.

Because the contraction of the acetate is much greater than that of the steel, the acetate material shrinks tightly on convex surfaces or surfaces of anchorage. But this same characteristic causes the material to shrink away when applied to concave surfaces or the interior surfaces of boxes or cylinders. If the pieces are large the shrinkage would be sufficient to make the application of an acetate coating impractical.

Experiments are now in progress to obtain better adhesion between the acetate and the metal backing. Appreciable improvement has been achieved but at present the bonding between the two materials cannot be depended on except in small simple pieces for normal use. Mechanical anchorage should be provided.

This process is not limited to cellulose acetate. Any thermo-plastic material can be used. Nor is it confined to the injection method of molding. However, compression molding is slower on account of the time required to heat and cool the mold; injection molding will produce five times as many pieces, using single cavity molds in both methods. Thus, the higher speed of injection molding will decrease the tool investment, in addition to which the production operations are faster.

Minimum thickness of the plastic coating is governed by the area to be covered and the maximum distance the material must flow. A thinner coating can be applied by compression molding than by injection molding but the saving in material cost is usually less than the higher operating cost of the compression method. The Chrysler injection molded panels have a coating 0.070 in. thick. The original molds were designed for a covering 0.050 in. thick but this was insufficient to hide the weld lines.

Metal stampings that are to be covered or coated with molded material should not have ribs or depressions for stiffening, which should be accomplished by curved surfaces or welded-on stiffeners. Ribs or depressions would result in thicker sections of acetate, thus causing shadows. But studs, brackets and other parts can be welded on and the opposite face covered with acetate.

To cover both faces of a metal stamping with acetate would require two molds, one for covering each side. This has probably never been tried and it would entail a considerable amount of experimental work before satisfactory production could be made.

Although the coating over the metal does stiffen the finished part, the amount is practically negligible as the coating is thin and the material is very flexible.

At the present time, press equipment is available for covering areas up to 20 in. by 20 in., or a maximum weight of molding material not exceeding 2 lb. No doubt, larger equipment will be built in the near future for producing pieces of much greater size.

Acetate covering is not limited to panels and sheets. Acetate over metal is employed in the new type automobile gear shift lever that is mounted on the steering column. The knob and rod is an unfinished forging covered with cellulose acetate. Formerly the forged rod was upset and threaded at one end and the plastic knob with threaded insert screwed on. The savings in the new acetate covered design are obvious.

This process of covering metal surfaces with plastics is new and up until now has been confined largely to automotive parts. There are, however, a vast number of fields in which it could be used to advantage, such as housings for office equipment, and camera parts and other parts requiring rigidity, unbreakable qualities and the superior finish that the acetate material provides.

Transparent Tenite injection molded over a spun aluminum head tightly seals this oil gage, gives a highly attractive finish and permits an undistorted view of the scale tape

GEAR CALCULATIONS

Based on Dynamic Loading and Wear Resistance

A. C. RASMUSSEN
Chief Engineer, Insley Manufacturing Corporation

PART II. Bevel gear tooth formulas based on the spur gear tooth formulas developed in Part I are here presented, an example is included to illustrate the method of applying the formulas

THE METHOD and procedure of designing gear teeth, by determining the dynamic tooth load and of keeping this load both within the beam strength and within the limit load for wear for the tooth section with margins of safety, were developed in Part I of this article which appeared in the preceding issue. In Part I formulas were established which apply to spur gear teeth. In this section of the article similar formulas will be established for bevel gear teeth.

The method used here in applying Prof. Buckingham's hypothesis to bevel gear teeth follows the logic developed by Prof. Leutwiler in his book "Machine Design."

Let Z = a ratio of the distance to the center of pressure on the tooth with respect to the distance to the outer edge from the apex. See Table VII for values.

and W_a = tooth load at center of pressure in a bevel gear

$$= \frac{W}{Z} \tag{44}$$

$$\text{then} \quad w = \frac{W_a}{f} = \frac{W}{f\,Z} \tag{45}$$

Referring to Equation (7) the dynamic tooth load can be written as

$$D' = fi + W_a \tag{46}$$

$$\text{then} \quad fi = \frac{0.05v\,(f\,C + W_a)}{0.05v + \sqrt{f\,C + W_a}} \tag{47}$$

in which

$$C = Z\,m\,b\ (48), \text{ and } v = \frac{\pi\,Z\,d_1\,n}{12} \tag{49}$$

Following the same procedure that was used to develop the spur gear formulas, the dynamic factor for bevel gears

$$d'_f = \left(1 + \frac{i}{w}\right)$$

$$= 1 + \frac{Z\,m\,b\,f}{126{,}050\ HP/d_1\ n} - \frac{27{,}120}{Z\,d_1\,n}\sqrt{\frac{HP}{d_1\,n}} \times J \tag{50}$$

$$\text{where } J = \sqrt{1 + \frac{Z\,m\,b\,f}{126{,}050\ HP/d_1\ n}}$$

And the dynamic tooth load for bevel gears can then be expressed as

$$D' = f\,w\,d'_f \tag{51}$$

The Lewis formula for bevel gear teeth written in terms of diametral pitch is

$$L' = \frac{\pi\,S_L\,f\,y\,g}{p} \tag{52}$$

Values of $\pi\,S_L$ are given in Table II.

Values of g, the reduction factor in the Lewis formula for bevel gears are given in Table VII for various ratios of face width to cone distance.

Stress is uniform along the tooth face at the plane of least strength and the tooth deflection is proportional to the distance from the apex. (See Leutwiler "Machine Design," Par. 239, Equation 358.)

The ratio factor Q for spur gears is dependent upon the numbers of teeth in the pinion and in the gear. With bevel gears it is a ratio that is dependent upon the formative numbers of teeth F_1 in the pinion and F_2 in the gear since this factor is dependent basically upon the radius of curvature of the gear tooth at the pitch line with respect to the radius of curvature of the pinion tooth.

Table VII—Values of *g*, *e*, and *z*

f/l_1	g	e	Z	f/l_1	g	e	Z
0.005	0.9950	0.9975	0.9975	0.205	0.8090	0.8975	0.9014
0.010	0.9900	0.9950	0.9950	0.210	0.8047	0.8950	0.8991
0.015	0.9851	0.9925	0.9925	0.215	0.8004	0.8925	0.8968
0.020	0.9801	0.9900	0.9900	0.220	0.7961	0.8900	0.8945
0.025	0.9752	0.9875	0.9876	0.225	0.7919	0.8875	0.8922
0.030	0.9703	0.9850	0.9851	0.230	0.7876	0.8850	0.8900
0.035	0.9654	0.9825	0.9826	0.235	0.7834	0.8825	0.8877
0.040	0.9605	0.9800	0.9801	0.240	0.7792	0.8800	0.8855
0.045	0.9557	0.9775	0.9777	0.245	0.7750	0.8775	0.8832
0.050	0.9508	0.9750	0.9752	0.250	0.7708	0.8750	0.8810
0.055	0.9460	0.9725	0.9728	0.255	0.7667	0.8725	0.8787
0.060	0.9412	0.9700	0.9703	0.260	0.7625	0.8700	0.8765
0.065	0.9364	0.9675	0.9679	0.265	0.7584	0.8675	0.8742
0.070	0.9316	0.9650	0.9654	0.270	0.7543	0.8650	0.8720
0.075	0.9269	0.9625	0.9630	0.275	0.7502	0.8625	0.8698
0.080	0.9221	0.9600	0.9606	0.280	0.7461	0.8600	0.8676
0.085	0.9174	0.9575	0.9581	0.285	0.7421	0.8575	0.8654
0.090	0.9127	0.9550	0.9557	0.290	0.7380	0.8550	0.8632
0.095	0.9080	0.9525	0.9533	0.295	0.7340	0.8525	0.8610
0.100	0.9033	0.9500	0.9509	0.300	0.7300	0.8500	0.8588
0.105	0.8987	0.9475	0.9485	0.305	0.7260	0.8475	0.8566
0.110	0.8940	0.9450	0.9461	0.310	0.7220	0.8450	0.8545
0.115	0.8894	0.9425	0.9437	0.315	0.7181	0.8425	0.8523
0.120	0.8848	0.9400	0.9413	0.320	0.7141	0.8400	0.8502
0.125	0.8802	0.9375	0.9389	0.325	0.7102	0.8375	0.8480
0.130	0.8756	0.9350	0.9365	0.330	0.7063	0.8350	0.8459
0.135	0.8711	0.9325	0.9341	0.335	0.7024	0.8325	0.8437
0.140	0.8665	0.9300	0.9318	0.340	0.6985	0.8300	0.8416
0.145	0.8620	0.9275	0.9294	0.345	0.6947	0.8275	0.8395
0.150	0.8575	0.9250	0.9270	0.350	0.6908	0.8250	0.8374
0.155	0.8530	0.9225	0.9247	0.355	0.6870	0.8225	0.8353
0.160	0.8485	0.9200	0.9223	0.360	0.6832	0.8200	0.8332
0.165	0.8441	0.9175	0.9200	0.365	0.6794	0.8175	0.8311
0.170	0.8396	0.9150	0.9176	0.370	0.6756	0.8150	0.8290
0.175	0.8352	0.9125	0.9153	0.375	0.6719	0.8125	0.8269
0.180	0.8308	0.9100	0.9130	0.380	0.6681	0.8100	0.8249
0.185	0.8264	0.9075	0.9106	0.385	0.6644	0.8075	0.8228
0.190	0.8220	0.9050	0.9083	0.390	0.6607	0.8050	0.8207
0.195	0.8177	0.9025	0.9060	0.395	0.6570	0.8025	0.8187
0.200	0.8133	0.9000	0.9037	0.400	0.6533	0.8000	0.8167

Table VIII—Gear Train Example, Size Calculations

Gear Pairs	First	Second	Third
SPUR GEARS			
N_2	37	50	81
N_1	16	17	22
R	2.31	2.94	3.68
Pinion r.p.m., n	1,500	649	221
Gear r.p.m	649	221	60
H.P. on driving shaft	50	48.5	47
Efficiency	0.97	0.97	0.94
H.P. transmitted	48.5	47.0	44.2
Assumed p	5	5	3
Assumed d_1	3.4 (l.a.)	3.6 (l.a.)	7.33
From Equation (19), k_3	0.5252	1.673	2.860
b	6	6	10
For m = 415, mb	2,500	2,500	1,150
f	1	1.25	2.50
mbf	2,500	3,125	10,375
From Equation (17), k_1	2.023	1.194	2.830
From Equation (20), k_2	0.916	2.479	5.598
From Equation (22), d_f	2.578	1.631	1.580
PINION DIAMETERS FROM EQUATION (42)			
M	718	718	311
s	0.90	0.90	0.90
Ms	646	646	280
$N_2 + N_1$	53	67	103
From Equation (42), $f d_1^2$	12.013	15.940	96.472
	1.0	1.25	2.5
$d_1{}^2$	12.013	12.752	38.589
d_1	3.466	3.571	6.212
Assumed d_1	3.40	3.60	7.333

Required diam. of first pinion is so little in excess of the assumed value that the assumed diam. will be considered satisfactory. Gear specifications will be selected as follows: (see next column)

Gear Pairs	First	Second	Third
PINIONS			
No. of teeth	16 (long add.)	17 (long add.)	22 (std. add.)
Diametral pitch	5	5	3
Outside diam	3.800	4.000	8.000
Mesh diam	3.400	3.600	7.333
Face in in	1¼	1½	2¾
GEARS, All standard addendum			
No. of teeth	37	50	81
Diametral pitch	5	5	3
Outside diam	7.800	10.400	27.667
Mesh diam	7.400	10.000	27.000
Face	1	1¼	2½
CENTER DISTANCES IN INCHES			
	5.400	6.800	17.167
CHECKING BEAM STRENGTH			
HP	50	48.5	47.0
From eq. (5) and (15), W	1,236	2,618	3,667
Dynamic tooth load D = $W \times d_f$	3,186	4,270	5,793
Material	2315 Carburized	2315 Carburized	1045 Oil quenched
$B.H.N.$	260	260	500
Interpolating from Table II, πS_L =	204,000	204,000	392,500
f	1¼	1½	2¾
y	0.094	0.096	0.105
From Equation (24), L	4,793	5,875	37,777
With s = 0.90, sL =	4,315	5,288	34,000

Note that as pinions are made with ¼ in. longer face than the gears, the beam strength is based on the longer face.

Since $F_1 = 2\,l_1\left(\frac{N_1}{d_2}\right)$ and (53)

$$F_2 = 2\,l_1\left(\frac{N_2}{d_1}\right) \quad (54)$$

The formative ratio is

$$F_z = \frac{F_2}{F_1} = \frac{N_2}{N_1} = \frac{d_2}{d_1} \quad (55)$$

or $F_z = R^2$ (56)

as $Q' = \frac{2F_2}{F_1 + F_2}$ (57)

then $Q' = \frac{2N_2^2}{N_1^2 + N_2^2}$ (58)

or $Q' = \frac{2}{\left(\frac{1}{R}\right)^2 + 1}$ (59)

As with spur gears

$$M = \frac{S^2 \sin\alpha}{0.70\,E_s} \quad (31)$$

The limiting static tooth load for bevel gears is then

$$A' = f\,Q'\,d_1\,Z\,M \quad (60)$$

As with spur pinions, the diameter of the bevel pinion can from Equation (60) be readily determined.

The ideal face width for bevel gears is considered to be one third of the cone distance l_1,

$$f = l_1/3 \quad (61)$$

and since

$$l_1 = \tfrac{1}{2}\sqrt{d_1^2 + d_2^2} = \frac{d_1}{2}\sqrt{\frac{N_1^2 + N_2^2}{N_1^2}}$$

$$f = \frac{d_1}{6}\,\frac{\sqrt{N_1^2 + N_2^2}}{N_1} \quad (62)$$

When f is taken at $l_1/3$, Z has 0.8444 for a numerical value.

The horsepower formula can be expressed as

$$HP = \frac{A'\,r_o\,n\,s}{63{,}025\,d_f} \quad (63)$$

where $r_o = \frac{Z\,d_1}{2}$, the radius of center of tooth pressure about center of rotation of pinion. (64)

Substituting in Equation (64) the foregoing values

$$HP = \frac{d_1^3\,M\,n\,s}{530{,}300\,d'_f}\,\frac{N_1^2}{N_1\sqrt{N_1^2 + N_2^2}} \quad (65)$$

from which

$$d_1^3 = \frac{530{,}000\,HP\,d'_f}{M\,n\,s}\,\frac{N_1\sqrt{N_1^2 + N_2^2}}{N_2^2} \quad (66)$$

In terms of the torque

$$d_1^3 = \frac{8.414\,T\,d'_f}{M\,s}\,\frac{N_1\sqrt{N_1^2 + N_2^2}}{N_2^2} \quad (67)$$

A good value of s is 85 to 90 per cent.

To illustrate the method and procedure in using the formulas, an example will be worked through. Table VIII shows the steps in the solution of the problem.

Example. A gear train using 20 deg. pressure angle, full depth, machined tooth gears is required to reduce the speed of a 50 hp. gasoline motor from 1500 r.p.m. (motor speed) to 60 r.p.m. Hunting tooth combinations are desired in the several pairs of gears.

(a) The motor pinion should be as small as practical to obtain the lowest possible pitch line velocity and also to keep the total number of teeth in the gear train to a minimum number. A motor pinion having 16 teeth wil be tried.

(b) For the pinion on the second shaft 17 teeth will be tried.

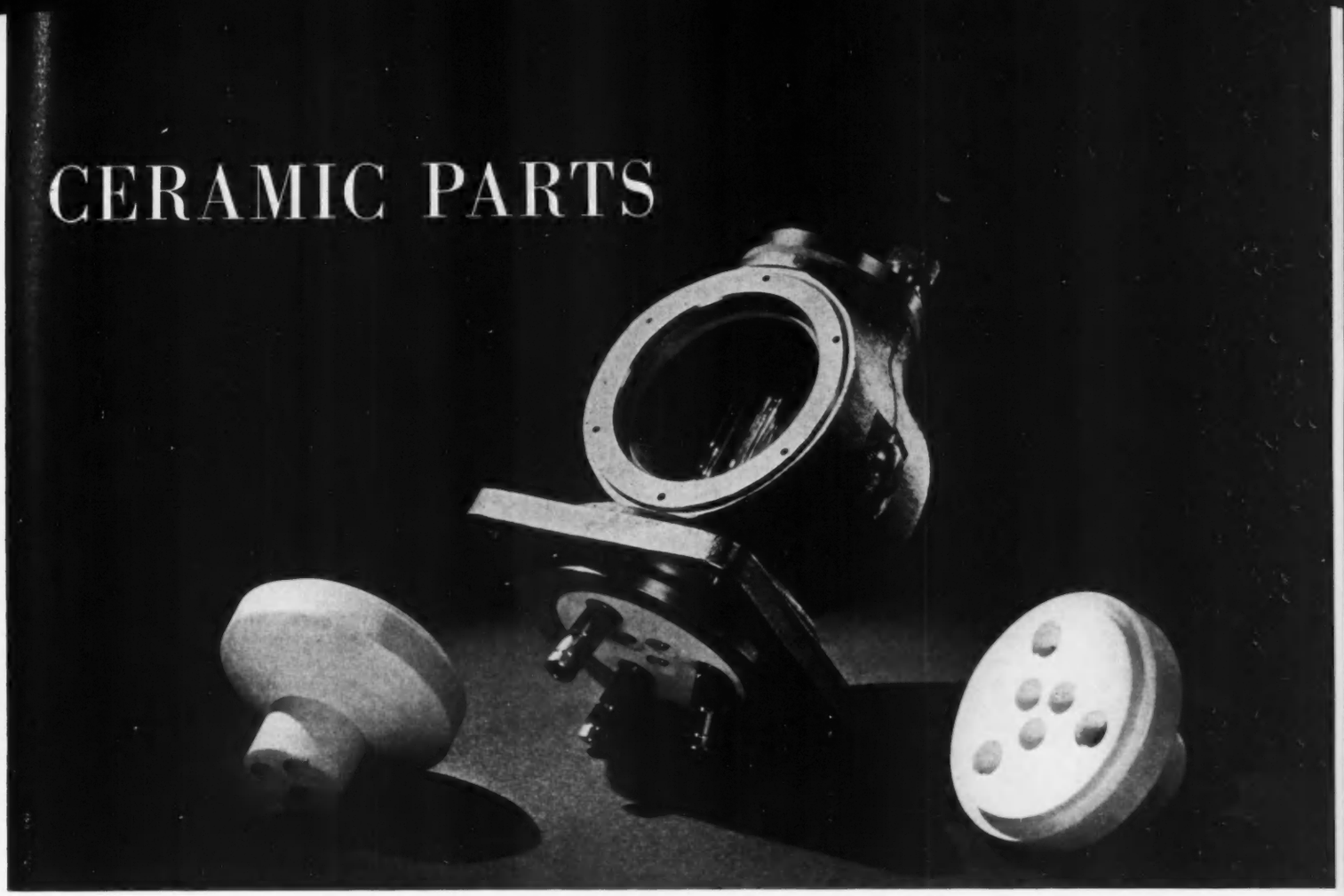
(c) Certain clearance requirements make it necessary to use a gear of at least 27 in. pitch diam. on the driven shaft and from experience it is known that a 3 diametral pitch 2½ in. face gear of this diameter will carry the load. Therefore 81 teeth and a face of 2½ in. will be tried for the driven or last gear.

With this data the number of teeth in the mating gears can by trial be selected as 37, 50 and 22 respectively.

A transmission efficiency of 0.97 will be assumed for the first and second pairs and 0.94 for the third pair.

For trial calculations it will be assumed that 5 diametral pitch will be satisfactory for the first and second pairs with a 1 in. face for the first pair and a 1¼ in. face for the second pair.

CERAMIC PARTS



General Electric Co.

Fig. 1—Water-cooled mercury projection lamp of high intensity uses Isolantite to insulate lamp elements and circulating pipes for cooling water

Typical mechanical and electrical applications of magnesium silicate ceramics in parts of machines and instruments with a discussion of the material's physical and electrical properties

HAROLD G. BEEBE
Isolantite, Inc.

AMONG the different types of materials grouped under the comprehensive heading of ceramics, the magnesium silicate group possesses physical, chemical and electrical properties which offer interesting possibilities for a wide range of uses, in both electrical and non-electrical applications. The best-known property of the magnesium silicate ceramics, that is their exceptionally low dielectric losses when used as insulators in a high-frequency field, has tended to overshadow other equally interesting properties.

Although the magnesium silicate ceramics, of which Isolantite is a typical example, are frequently classified somewhat loosely under the heading of "porcelains," they have little in common with porcelain except in physical appearance. The essential raw material in the manufacture of porcelain is clay, which produces entirely different characteristics from those distinguishing magnesium silicate ceramics.

In brief, the magnesium silicate ceramics may be said to be characterized by high mechanical strength, chemical inertness, and low electrical losses. In the elaboration of these points, this article does not purport to offer an exhaustive study of all of the properties of this material under varying conditions of application, nor to mark off definite boundaries separating the applications for which Isolantite is suitable from those for which some other material is preferable. A summary of the outstanding properties of the material, together with a discussion of some of its general industrial uses, will, however, serve as a basis on which the design engineer may form preliminary decisions as to the potentialities of the material for his particular problem.

In considering the physical properties of this special group of ceramics, it is advisable to emphasize at the outset that breaking strength values cannot be listed with the same degree of

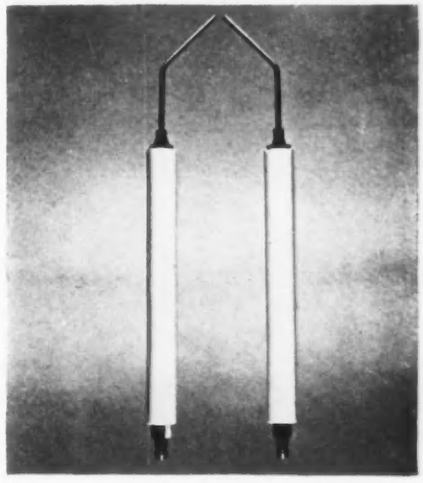


Fig. 2—Oil burner ignition electrodes in which Isolantite tubes are casings

definiteness as for metals. The strength of a ceramic article depends very largely upon the section of the article. Test specimens which do not resemble commercial articles are frequently of little value in determining the strength of a specific part. In considering the suitability of a ceramic for a particular application, it is therefore advisable to obtain data based on the shape in question. The values given here for mechanical strength are to be considered only as general indications. For example, an

Isolantite bar in tension where the full cross-section is utilized will develop an average breaking strength of 5,000 lb. per sq. in. in a bar of 1 in. diam. and 7,000 lb. per sq. in. in a bar of ½ in. diam. The same bars in cantilever loading will have an average modulus of rupture of 15,000 and 20,000 lb. per sq. in. respectively.

Under tension the values for mechanical strength are markedly affected by the shape of the section and the method of suspension. Under favorable conditions, as when parts are assembled with cemented metal énd caps, breaking strength will frequently be above 6,000 lb. per sq. in. Cemented end caps are in common use although they do not provide the best electrical construction. Under the least favorable conditions, that is, when the cross-section area is sacrificed for mounting or supporting purposes, such as holes through bars for cables in strain insulators, the breaking strength is usually in excess of 2,500 lb. per sq. in. Between these limits it is ordinarily possible, by a process of selection, to furnish parts meeting definite strength specifications.

Under compression the value for ultimate strength is approximately 100,000 lb. per sq. in. The ratio of thickness to area influences the compressive strength. A part with a semi-spherical end uniformly loaded is the strongest shape under compression, also a cylinder with flat ends and a length equal to the diameter is a good shape to support compressive loads. The strength under transverse loading, as measured by the modulus of rupture, generally exceeds 15,000 lb. per sq. in. and values as high as 20,000 lb. per sq. in. are often obtained.

A highly important characteristic of Isolantite, particularly when applied as an insulator, is its stiffness. The material has a modulus of elasticity of 15,000,000 lb. per sq. in. The thermal coefficient of expansion of this material is relatively low, measured at 20 deg. C., the value is 0.000007 per deg. C., and the material is not subject to deterioration at temperatures encountered in normal service.

Considered from the chemical standpoint, magnesium silicate materials are suitable for the manufacture of parts subjected to the action of acids, as they are almost completely inert to the action of all acids except hydrofluoric. Ceramics in general are not highly resistant to alkalis. However, the steatite ceramics are more resistant to alkalis than clay porcelains, and can be used in contact with alkalis for short periods of time. An interesting application made possible by this characteristic is the packing for reaction towers. Under normal operating conditions, the material used for packing is exposed only to acid attack. When the tower is cleaned, however, the packing is washed down with an alkaline solution, and the material must withstand attack for short periods of time, and resist penetration. Isolantite has been found to give entirely satisfactory results in this service.

Electrically, Isolantite has excellent insulating properties, the average volume resistivity, determined by a series of tests under varying conditions, is 10^{14} ohms per c.c. its non-absorbent body is an advantage in electrical applications also, as volume resistivity is almost entirely unaffected by moisture. Surface leakage resistivity, determined under conditions paralleling actual service, ranges from 10^{14} to 10^{16} ohms per sq. cm., with an average value of 10^{15}. These values are based on clean insulators.

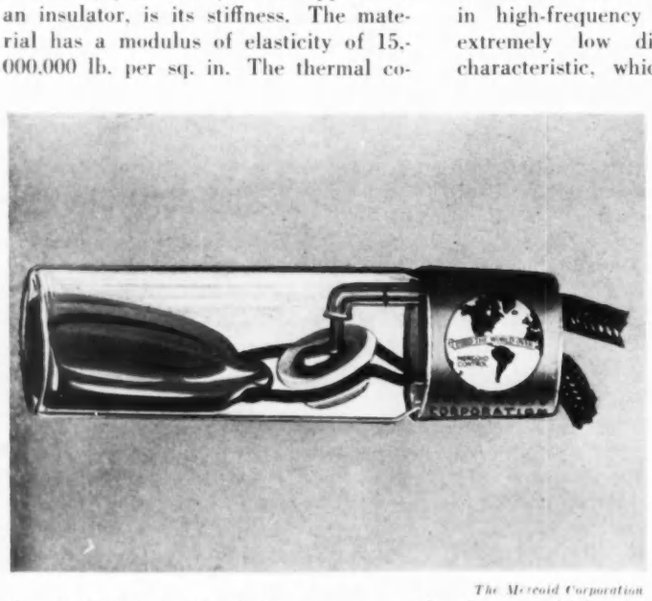
Another electrical property of this material, which is especially desirable in high-frequency applications, is its extremely low dielectric loss. This characteristic, which plays little part in the design of industrial electrical equipment, is an essential factor in the manufacture of radio and communications apparatus.

While this summary of inherent characteristics may serve to guide the product designer in determining suitability for various uses, it is necessary to sketch briefly the manufacturing processes of the material, and the limitations of size and cost economy which these processes impose.

In general, Isolantite may be either molded to a finished shape, or extruded in the form of rod, bar, or tube. Unfired stock which has been pre-formed by extrusion or any of the molding process can subsequently be machined by practically any of the ordinary machining operations. Holes can be drilled and tapped; slots can be cut; the piece can be threaded. Obviously, the amount of machining necessary markedly affects the cost of the piece. Where the piece is of such a size and shape that it can be conveniently molded in a single operation, expense of machining can be eliminated, but die costs are involved. The decision as to the best method of manufacture of a specific piece is best arrived at in consultation with the supplier. Considerations both of production economy and the necessity of securing a homogeneous body affect the size of piece which it is possible to produce.

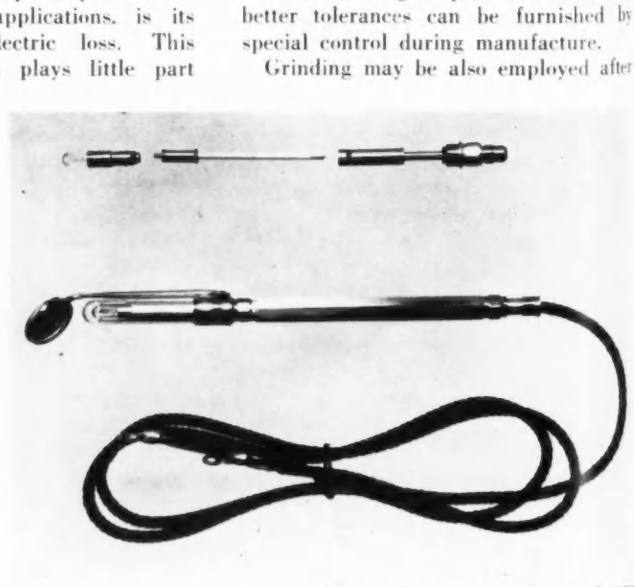
Lowest costs can be obtained when tolerances of plus or minus 1 per cent are allowed for dimensions over one half inch, and for dimensions under one half inch a somewhat greater percentage tolerance is frequently required to meet minimum costs. Certain critical dimensions of a part may generally be held closer without material increase in price. At somewhat higher prices, substantially better tolerances can be furnished by special control during manufacture.

Grinding may be also employed after



The Mercoid Corporation

Fig. 3—Sealed switch of the instantaneous-break type which uses an Isolantite cup to hold a pool of mercury



The S. S. White Dental Manufacturing Company

Fig. 4—Mouth lamps used for dental operations in which small Isolantite tubes form the insulation between electrical circuits

articles are fired to produce pieces to very close tolerances, at costs comparable to the grinding of steel. As with any other material used by the product designer, the stipulation of tolerances closer than normal involves a sharp rise in production costs, and should be avoided unless absolutely necessary.

The potential uses of magnesium silicate ceramics are so varied that it is impossible, within the compass of this article, to do more than indicate by reference to the few specific applications illustrated the direction of possible uses in other products.

An interesting group of special applications of Isolantite as an insulating material comprises several uses in the fields of therapy, surgery, and dental surgery. Small blocks of this material are used as insulation in the construction of X-ray tubes. Dental mouth lamps, cautery instruments, and conization electrodes are other types of equipment using this type of insulation. In such applications space requirements are usually extremely limited, the insulating material must have high mechanical strength in small sections, and must be formed with a high degree of dimensional precision to permit easy, economical assembly.

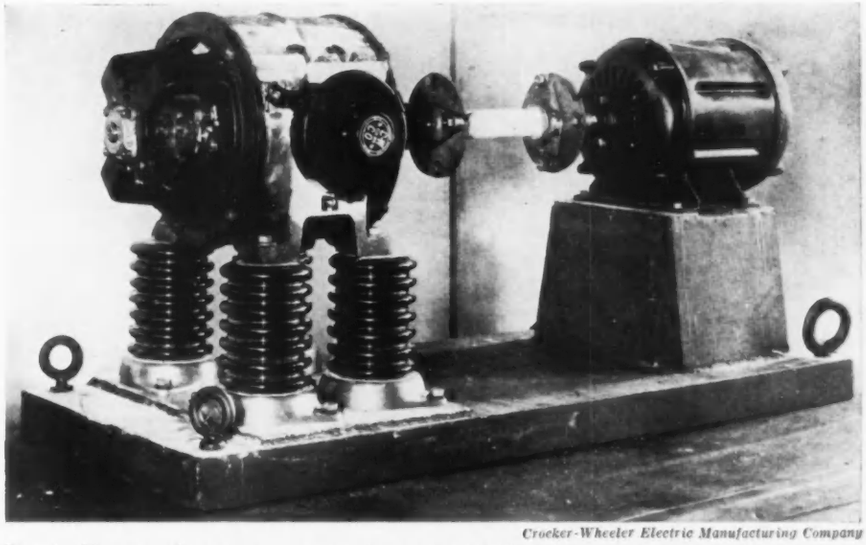
A newer application for this ceramic material is in the construction of a water-cooled mercury projection lamp which is in the course of development, where it serves to insulate the elements of the lamp, and also to insulate pipes used to circulate cooling water for the lamp. This lamp, which has a brightness ten times that of the brightest tungsten lamp, is expected to find application in many photographic processes and in lithography.

An application in which both the electrical and mechanical properties of this material are utilized is a coupling shaft used between the motor and the generator of equipment used to generate current for lighting the towers of radio stations. Here it is essential that the frames of the motor and of the generator be insulated from each other, an Isolantite rod, used for insulation, serves also as the intermediate shaft between the motor and generator.

Magnesium silicate ceramics are extensively used by the oil burner industry as the insulating material for the burner electrodes. Its high mechanical strength permits reduction in the size of the insulators without sacrifice of electrical safety factor. Imperviousness to oil and moisture are important factors in this service.

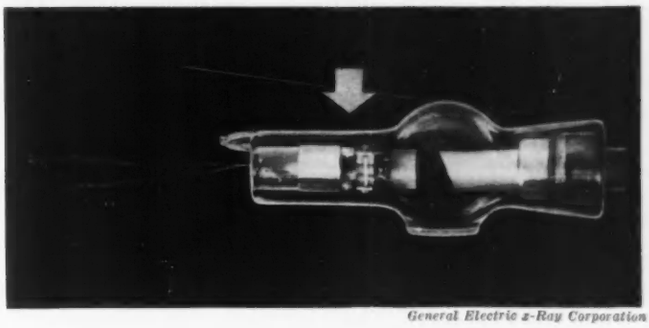
In the chemical industry, in addition to the reaction tower packing mentioned, Isolantite is used for the manufacture of valve parts, particularly where acids are to be handled.

Further exploitation of this ceramic, long established in the radio field but comparatively new as a general industrial material, is expected to open up many new possibilities.



Crocker-Wheeler Electric Manufacturing Company

Fig. 6—Motor and generator in a radio tower lighting set are connected with an intermediate drive shaft made of Isolantite which also serves as an insulator

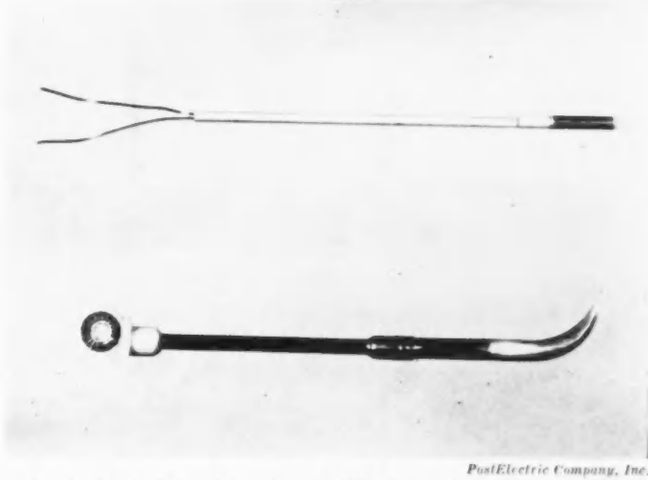


General Electric x-Ray Corporation

Fig. 7—X-ray tube in which small blocks of Isolantite are used as insulators

I. Greenwald Company, Inc.

Fig. 8—Cautery instruments which use Isolantite for the heating element cores and for the lead wire insulating tubes



PostElectric Company, Inc.

Fig. 5—Conization electrodes and loops used in physical therapy employ Isolantite parts in their construction

COMPRESSION SPRING

In many installations where compression springs are used, adjustability of the spring tension is frequently required. The methods shown incorporate various designs of screw and nut adjustment with numerous types of spring-centering means to guard against buckling. Some designs incorporate frictional reducing members to facilitate adjustment especially for springs of large diameter and heavy wire

HENRY MARTIN

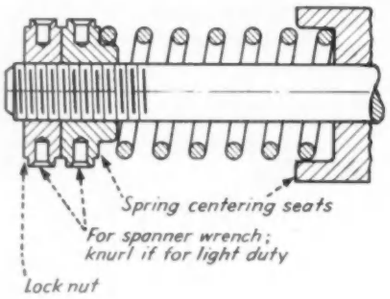


FIG.1

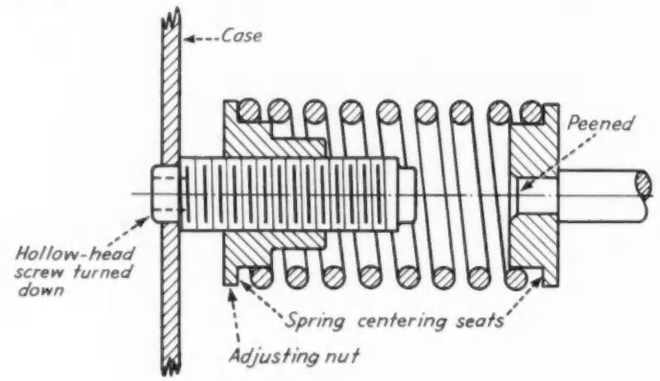


FIG.2

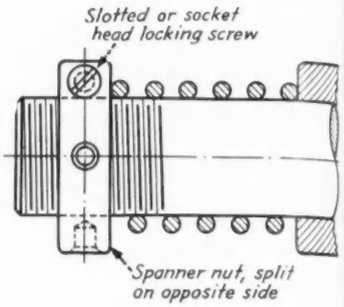


FIG.3

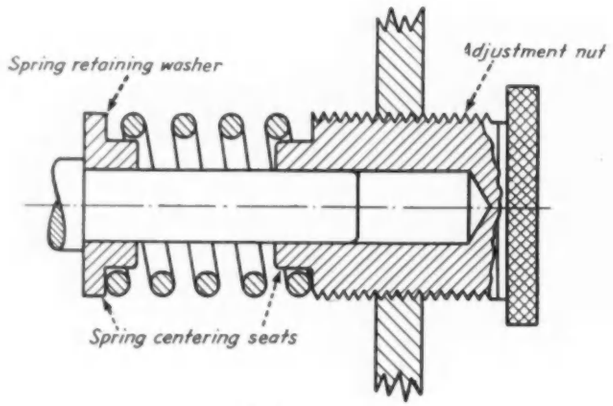


FIG.4

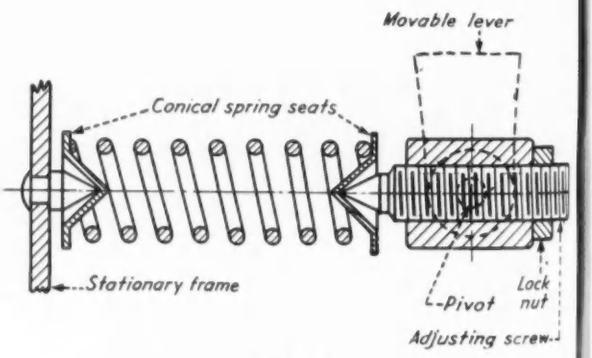


FIG.5

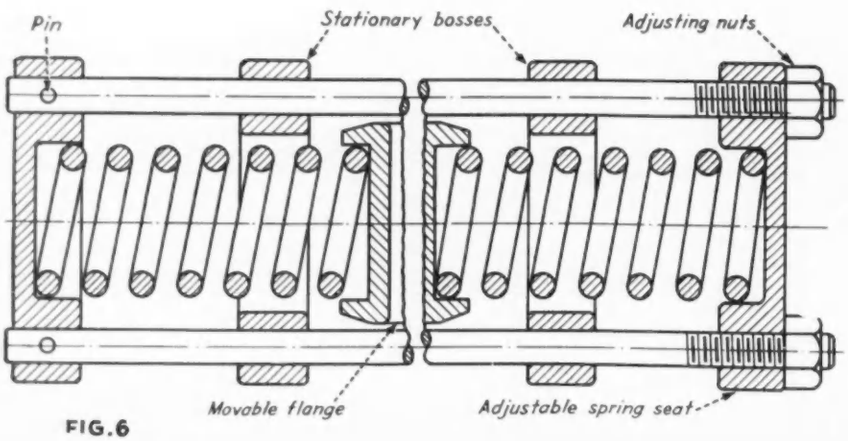


FIG.6

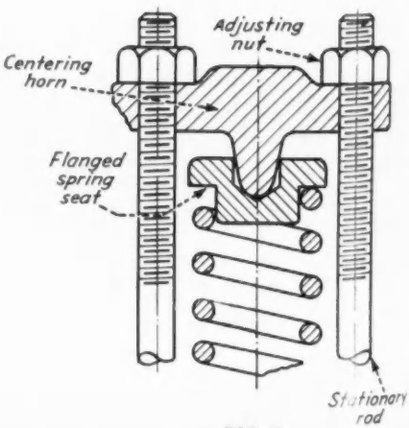


FIG.7

ADJUSTING METHODS–I

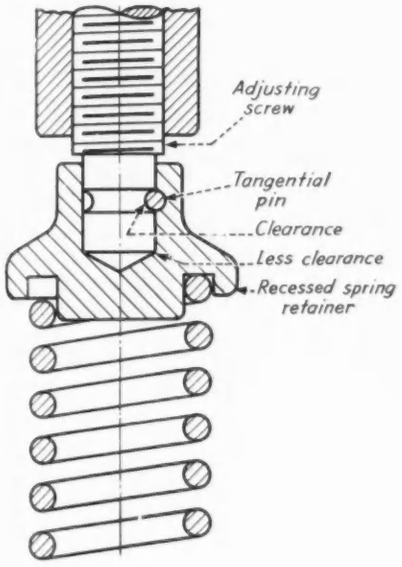


FIG.8

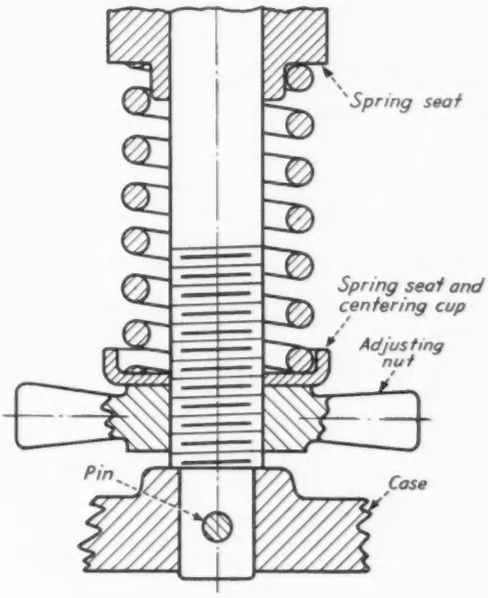


FIG.9

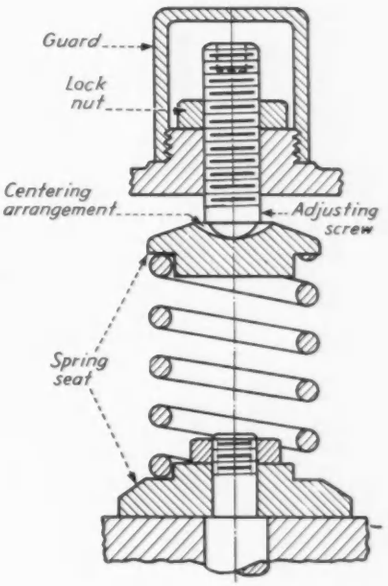


FIG.10

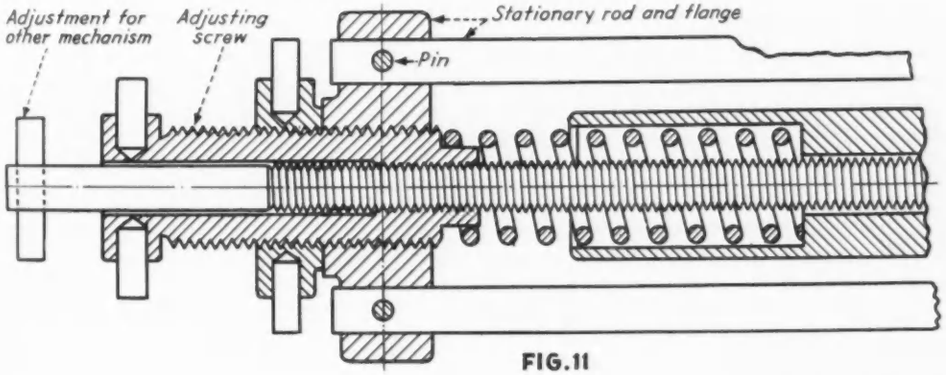


FIG.11

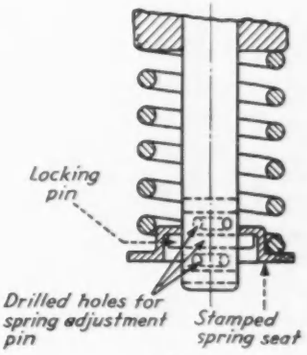


FIG.12

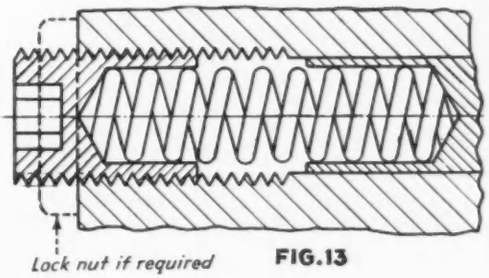


FIG.13

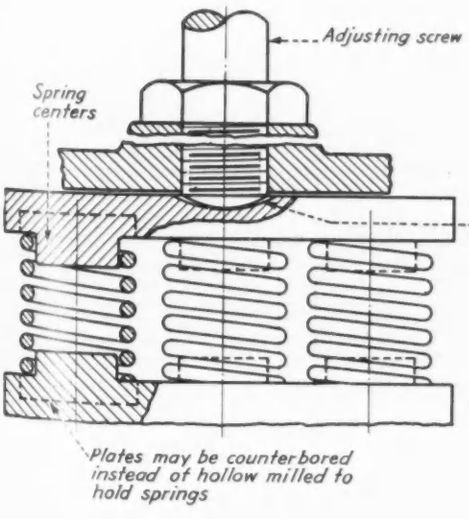

Adjusting screw
Spring centers
Rounded to equalize spring pressure
Plates may be counterbored instead of hollow milled to hold springs

FIG.14

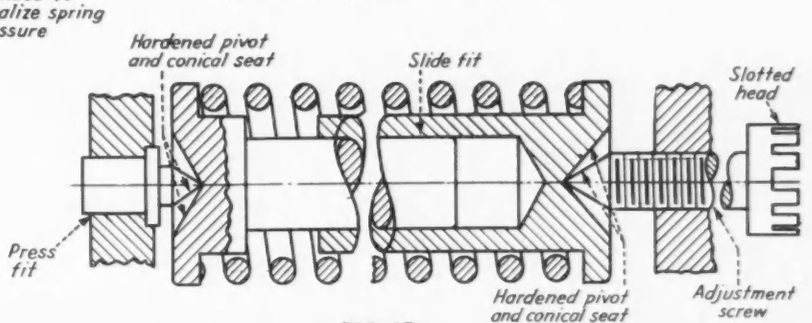


FIG.15

Question and Comment

Effect of Rotation on Shrink-Fit Stress

MERHYLE F. SPOTTS
Johns Hopkins University

When a shaft, which has a hub or disk shrunk on, is rotated, the centrifugal forces produced cause outward radial displacement of the disk or hub a greater amount than the shaft, thus reducing the original contact pressure. The resulting pressure which exists between the disk and shaft may be obtained by combining the known equations for shrink fits and rotating disks.

The equation given in books on strength of materials (for example Timoshenko "Strength of Materials," Vol. II, pp. 528-545, Van Nostrand) for the contact pressure p_c, produced by a shrink fit between a disk and a solid shaft is

$$p_c = \frac{E}{2}\left(1 - \frac{a^2}{b^2}\right)\frac{\delta}{a} \qquad (1)$$

where E is the modulus of elasticity for the material, assumed to be the same for both disk and shaft, a is the radius of the shaft, b is the outer radius of the disk, and δ is the amount by which the radius of the shaft exceeds the radius of the hole in the disk.

When a disk of uniform thickness, having a hole radius of a and an outer radius b is rotated, the increase u of the radius of the hole is given by

$$u = \frac{Kab^2}{8}\left[\frac{3+\mu}{1+\mu}\left(1+\frac{a^2}{b^2}\right) + \frac{3+\mu}{1-\mu} - \frac{a^2}{b^2}\right] \qquad (2)$$

where μ is Poisson's ratio. The constant K is given by

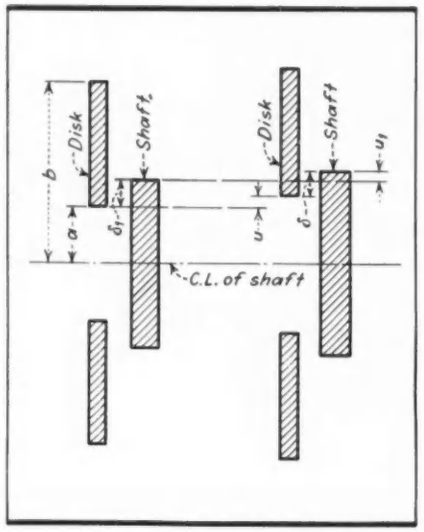
$$K = (1-\mu^2)\frac{\rho\,\omega^2}{g\,E} \qquad (3)$$

where ρ is the weight per unit volume of the material composing the disk, ω is the angular velocity in radians per sec., and g is the acceleration of gravity.

Similarly the radius of the shaft will be increased by

$$u_1 = \frac{Ka^3}{8}\left[\frac{3+\mu}{1+\mu} - 1\right] \qquad (4)$$

The foregoing formulas can be utilized to evaluate the case of combined shrink fit and rotation. The figure shows a disk of inner radius a and outer radius b together with a short length of the shaft whose radius is greater than that of the hole by an amount δ_1. When both shaft and disk are rotating at an angular velocity of ω radians per sec., the inner radius of the disk is increased by the amount u, and the radius of the shaft is increased by u_1.



Shrunk-fit disk on shaft before and during rotation

From the figure,

$$\delta = \delta_1 - u + u_1 \qquad (5)$$

Substituting the values of u and u_1 from equations (2) and (4), we obtain

$$\delta = \delta_1 - \frac{Kab^2}{4}\left(\frac{3+\mu}{1-\mu^2}\right) \qquad (6)$$

By substituting this value of δ in equation (1), the value of the contact pressure when shaft and disk are rotating is obtained. Performing this operation, together with the substitution of the value of K from equation (3) yields

$$p_c = \frac{E}{2}\left(1-\frac{a^2}{b^2}\right)\left[\frac{\delta_1}{a} - \frac{(3+\mu)\,\rho\,b^2\,\omega^2}{4\,g\,E}\right] \qquad (7)$$

This value of p_c is of course the compressive stress in the radial direction in the disk at its inner boundary.

If the material under consideration is steel, $E = 20{,}000{,}000$ lb./in.^{2} $\mu = 0.3$, and $\rho = 0.283$ lb./in.^{3} Further, $\omega = \frac{\pi N}{30}$ where N is the number of revolutions per minute, and g is 32.2 × 12 in./sec.^{2} Using the above values, equation (7) reduces to

$$p_c = \frac{1}{2}\left(1-\frac{a^2}{b^2}\right)\times\left[30{,}000{,}000\,\frac{\delta_1}{a} - 0.00000663\,b^2N^2\right] \qquad (8)$$

As a numerical example, take $a = 3$ in., $b = 10$ in., $\frac{\sigma_1}{a} = 0.001$ and $N = 3{,}600$ r.p.m. From equation (8) contact pressure $p_c = 9{,}740$ lb./in.^{2}

This result may be compared with 13,650 lb./in.^{2} contact pressure when the parts are not rotating as given by equation (1). If p_c in equation (8) is set equal to zero, the speed at which contact pressure vanishes can be computed; in the foregoing example this would occur at 6,730 r.p.m.

The stress in the tangential direction S_t, may also be obtained by combining the effects of rotation and shrink fit. At the inner boundary of the disk, rotation stress is

$$S_t = \frac{\rho\,b^2\omega^2}{g}\,\frac{3+\mu}{4}\left(1+\frac{1-\mu}{3+\mu}\,\frac{a^2}{b^2}\right) \qquad (9)$$

The stress caused by shrink fit is given by

$$S_t = \left(\frac{b^2+a^2}{b^2-a^2}\right)p_c \qquad (10)$$

where p_c is obtained from either equation (7) or (8). Total stress is obtained by adding equations (9) and (10) giving

$$S_t = \frac{\rho b^2\omega^2}{g}\times\frac{3+\mu}{4}\left(1+\frac{1-\mu}{3+\mu}\,\frac{a^2}{b^2}\right) + \left(\frac{b^2+a^2}{b^2-a^2}\right)p_c \qquad (11)$$

For the foregoing example this tangential stress is 20,430 lb./in.^{2} at the inner boundary of the disk.

Machinability of Steels

To the Editor:

The writers of the article "Machinability of Steels" which appeared in the January 1939 number of *P.E.*, page 12, in so far as I can see, mention hardness but once and there only refer to "various Brinell hardness values" but give no real figures. Is it possible that they do not

know that hardness, to some extent, limits the rates of machining? Is it possible that they would attempt to classify hot rolled, cold rolled and annealed under the same comparative values?

There is no appreciable difference in the machinability rates of steels until one gets into heat-treated steels with a Brinell hardness of 255 or Rockwell hardness of 25 *C*. Modern cutting materials have made a lot of conversation about the cutting rates of steel unnecessary.

I have been working with carbide tools and have found that hardness is the only real property of steel to consider when using them. There is no appreciable difference in the cutting rates, although a different grade of carbide for the higher alloys and for the low alloys or for the straight carbon steels would be necessary.

I would like to ask the authors what rates of speed they would consider "fair" when machining say SAE 1112 steel. With carbide tools the reply would be: if the depth of cut is $\frac{1}{16}$ in., and the speed 0.012 in., then the speed would be 600 or even as much as 900 surface ft. per min. depending on the machine.

—C. G. Williams,
Davenport, Iowa.

To the Editor:

Referring to the letter from Mr. Williams whose criticism we deeply appreciate, if he will examine the chart given in the article he will note that the Brinell hardness for each particular steel mentioned is specifically plotted. While hardness has a direct influence on machinability, it must be remembered that such other factors as shearing strength, ductility, the effect of mass ferrite in steels below 0.30 per cent carbon and grain size are also factors which cannot be ignored.

With the use of carbide tools and special heavy duty machine tools, it is possible to obtain machinability values greatly in excess of those being obtained in a great many plants. These plants, however, are doing a great variety of work and are more or less specification shops. Due to the high first cost of specially built machine tools they are necessarily limited to the use of average fabricating equipment and 18-4-1 high speed tools. It was this type of plant for which we believed a relative machinability chart would be of value.

It is also possible with 18-4-1 tools under ideal conditions to exceed the machinability values shown in the chart. It must be remembered that the values quoted are the general average for a great variety of work over a long period of time and should only be regarded as such. But, we believe that there are a great number of specification shops where the number of pieces of work for each operation is necessarily small, while the variety of work is very large. This makes it difficult to justify the purchase of highly individually specialized machine tools, and it is with this thought in mind that the machinability chart was published.

In regard to the question of what we could consider a fair speed for SAE 1112 steel we find that our latest tables give us surface speed of 175 ft. per min. with 0.035 in. depth of cut, and 0.062 in. speed. This is with 18-4-1 tools using no coolant for a semi-finish cutting operation. The example quoted in the article was not a practical problem, and was intended to illustrate a method of selecting a material, giving due consideration to machinability, rather than attempting to typify the rate of machining arrived at in practice. —James Sorenson
The Four Wheel Drive Company
Clintonville, Wis.

To the Editor:

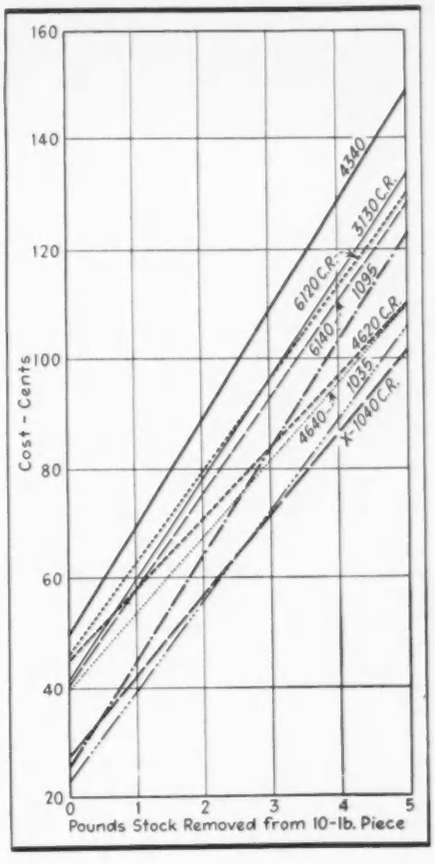
While we appreciate that the example given in this article was merely for purposes of illustrating the general value of machinability ratings, we would like to point out certain factors that an engineer must take into account. While your Table 3 was established on the basis of steels selected according to their tensile properties, it must be remembered that this is not the only important item to be considered. Quite often the structural conditions of the materials themselves are of equal importance.

It is even conceivable that if the basis of selections for the steels were other than tensile value, striking differences in machinability ratings would have made your problem even more forceful. The closing paragraph of the article where you point out some of the possibilities of heat-treating, carburizing or other possible operations to be performed, indicates how the selection of the correct steel may become difficult, as the number of steels suitable for a specific purpose will be greatly increased.

It is my belief that too great an emphasis cannot be placed on the value of machinability ratings particularly as the percentage of raw stock to be removed and the number of parts to processed increases. However in no case should metallurgical limitations be neglected in an effort to get low costs. Close cooperation with the metallurgist is essential if the final design decision is to be correct. —W. R.
Chicago, Ill.

To the Editor:

Your article on the machinability of steels in the January number is most interesting and it is to be regretted that the figure which included the original cost of materials had one or two errors in it which spoiled the accuracy of the article. For example, 25 cents extra should be added to the base price of the S.A.E. 1095 steel. I also note that you



have not allowed for the differential charge for S.A.E. 4300 steel, which will actually make it the most expensive steel in the table.

I am forwarding herewith a corrected chart which gives a slightly different picture. While I believe this figure is basically correct every engineering department should get exact costs of raw materials from its purchasing department before making a selection.

—Ed. West
Oak Park, Ill.

Auction Problem

To the Editor:

The solution to the animal auction problem by H. E. Smith in your January number can be made much more elegantly. By clearing the second equation of fractions, (noting that the 2 under the Z has been dropped by printer's error), subtracting the first equation from the second and solving for y, we have

$$y = \frac{100 - 19x}{5} \quad \text{or} \quad y = 20 - \frac{19x}{5}$$

By inspection, x must be a multiple of

5 in order that the second term may be integral, and it cannot be more than 5 if y is to be positive. Therefore, 5 is the only permissible value for x.

Where there is one more variable than equations, as here, the solution is indeterminate and there will be an infinite number of sets of values for the variables as solutions. If these values are restricted to positive integers, as they are by the nature of this problem, the number is greatly reduced: in this case, the number reduced to one. —CARL P. NACHOD

Nachod & U.S. Signal Company

Not Too Modern, Please

HAL FALVEY

W. W. Garrison & Company

What the public seems to want is not something new at all, but what they have always had, done up in a new, but not-too-new package. Contrasting design experience of an automobile manufacturer and a fountain pen maker serve to illustrate this point. The car builder rashly outpaced the public a while back, producing an automobile with the general lines of a widely-publicized racing car. The wheels were scarcely visible, the radiator, hood, top and tail rolled back in one suave line, and the interior was reminiscent of an air liner. The designers were sure it would captivate the public. But it didn't: it was too advanced. People shied away from it. Some wealthy people of presumably advanced tastes did purchase, but not enough to keep a production line going. Proof that the trouble was in the too-advanced design lies in the fact that when the same car's lines were brought into more harmony with what the public thought a car should be like, sales responded nicely.

Compare that with the experience of the fountain pen maker who did it right the first time. In order to make his pen and its advertising distinctive, he used streamlining. He put a bullet-shaped end on the cap of the pen, and another on the quill, completely abandoning the traditional baseball bat-shape used for decades.

As with the automobile, the new pen lines suggested speed and facility, both desirable in a writing tool. A wholly new impression was achieved. But note that the pen still came in two parts: a cap and a barrel. The barrel still had the familiar pen point on it, and the cap retained its old-time pocket clip. The whole thing was new, but not too new. And its sales have soared, and led the industry since.

Examples can be multiplied. There was the very successful coin-operated weighing machine newly re-designed, yet retaining the familiar coin slot, platform and dial exactly where they had been on earlier models, plus the canny thought of printing "Step On It" on the weighing platform, in case the public didn't catch on that it was a weighing machine. Such design couldn't fail. It was new, but not too much so.

Then, for contrast, a manufacturer produced a telescopic light metal duckboat. In every field test it was a dandy. But hunters are set in their ways, chary of new things. It didn't look like a punt to them. Not enough, anyway. They wouldn't even try it. And so this article was not a commercial success.

It comes down to this: Product designers have gone miles ahead down a route that the public hasn't traveled yet. But people instinctively shy at the unfamiliar. They must be led slowly, by the hand, along the road the designers long since traveled. Better to design the ultimate article, and then backtrack a bit before trying to sell it, than to lose the all-important tie-up with whatever design has gone before. After all, the idea is to sell the product.

How, then, can one tell when a design departs dangerously from its ancestors? The best way is to give it a try-out with actual prospective purchasers. Be sure they do not know this is a test, or their sudden self-consciousness will blur the spontaneous reaction you want. If such a test is not feasible, then one can only sit back and look coldly at the new design and decide whether it is too radical to sell and whether it plainly states its purpose. This is not easy, beset as you will be by the temptation to take out all the newness.

And so, out of much experience marketing devices designed by product designers, the only practical guide that has emerged for me in judging the salability of any design is summed up readily: "not too modern, please!" Else people will gape at your product, but they won't lay down their money for it.

Clutch Problem

To the Editor:

In a certain single-plate clutch installation, the following data apply:

Load .....800 lb.
Outside diameter clutch facings..10 in.
Inner diameter clutch facings.....6 in.
Torque arm of facings.....0.34 ft.
Effective area, both facings..0.697 sq. ft.
Total inertia load ...1.75 ft.lb. per sec.^{2}

A similar installation is contemplated for a larger clutch of the same type. This larger clutch should be under a strain proportional to that of the smaller clutch in its installation. Data on the larger clutch:

Load .....1200 lb.
Outside diameter clutch facings.$10\frac{3}{4}$ in.
Inside diameter clutch facings....7 in.
Torque arm of facings .....0.374 ft.
Effective area, both facings..0.727 sq. ft.

My problem is to compute the total inertia load which will produce in this clutch a strain proportional to that produced in the smaller clutch. In solving, following two different lines of reasoning, I have arrived at two different answers. I should appreciate any help that your readers may be able to extend.

—F.W.L.

Detroit, Michigan

Can You Work This One?

H. E. SMITH

Solution to last month's problem—

On a Bicycle Built for Two

Tom and Harry rode the tandem for a distance of thirty miles, while Dick walked six miles. At the thirty-mile point, Harry continued his journey afoot and Tom pedaled back towards Dick. They met at a point ten miles from the start of their journey, since at their respective speeds Tom covered twenty miles back while Dick walked forward four miles. In the meantime, Harry had walked five miles toward the destination. Tom and Dick, riding tandem, raced toward the destination covering the 33 1/3 miles in the same time that Harry proceeded 8 1/3 miles. Thus the three reached their destination simultaneously, with a total elapsed time of four hours and ten minutes to cover the total distance of 43 1/3 miles.

This month's problem—

Forward March!

During a recent St. Patrick's Day parade, the men in the procession marched ten abreast. One of the brethern in the last row ducked into a tavern for a short beer. Naturally he failed to return to the line of march. The Grand Marshal tried to reorganize things on the basis of nine men to the row, as eleven would not do. It was discovered the last row came out with eight men. He then tried successively eight, seven, six, five, four, three and two abreast, but in every case, the last row was one man short. What was the minimum number of Irishmen in the parade?

News

Electronic Lighting Permits 1/100,000-Sec. Film Exposures

New photographic technique developed by Spalding research laboratory will aid analytical studies of complicated motions

A NEW PROCESS of photography, at a greater degree of speed than ever before—to 1/100,000 sec. exposure—has been developed by A. G. Spalding & Bros. The demonstration of the process was made coincident with an announcement of the establishment of a research department as a separate division of the company, incorporating Spalding's testing laboratory at Chicopee, Mass., the largest sporting equipment laboratory in the world.

The research division will be under the direction of Dr. J. B. Dickson, who has been on the Spalding scientific staff for the last fifteen years. Consultants of the department are George S. Radford, consulting engineer, and Arthur D. Little, Incorporated, of Cambridge, Mass. The activities of the research department are coordinated with the other activities of the company, and will extend to the sports field the same research technique which has been successfully applied in the automobile, electrical goods and chemical industries.

Many of the photographs shown at the demonstration illustrated Dr. Edgerton's most recently developed technique, multiple high speed exposure, in which successive exposures of 1/100,000 sec. each are made at rates up to 600 per sec. Even single exposures timed as short as 1/100,000 sec. are very far beyond the range of the conventional camera where top exposure is limited to about 1/1500 sec. by the obvious difficulty of moving a mechanical shutter and the inadequacy of usual light sources. In this case the ultra-speed photography was used for the study of the game of golf, but it can be applied to the photography of rapid motion in any field.

Photography with such short exposures is possible by the use of modern electronic lighting and control devices, by which shorter exposures are possible and the timing of the flashes is under accurate control. With the new process, light from gas-filled tubes can be controlled accurately so that intense flashes of light occur at exactly spaced intervals of time in almost any desired fashion. The exposure time is determined by the duration of the flash of light from a gas-filled tube and not by a mechanically moving shutter. This is accomplished by the sudden release at the desired time of electrical energy stored in a condenser. By taking superimposed photographs at successive intervals of time, a composite photograph of a complicated motion can be made.

Summary of Recent Research on Silver

SPONSORED by a group of leading American silver-producing companies, the metallurgical program has advanced to the point where tensile test data have been obtained showing the effect of small additions of silver on the properties of a number of commercial alloy types. Were silver as low priced as the more common alloying elements, the improvement in properties resulting from addition of a small percentage of silver would be of great practical interest. At the present price of silver, each per cent of silver added increases the cost of the alloy 6¼ cents per lb. The improved properties commented on below must be balanced against the cost of the silver needed for the improvement. The data on which the observations are based appear in the Seventh Progress Report prepared by the research associates at the National Bureau of Standards.

The following alloys showed that adding about 5 per cent silver notably increased the yield strength of the wrought alloy without commensurate loss in ductility: 80–20 cupronickel, alpha brasses, 5 and 10 per cent tin bronzes, 5 per cent aluminum bronze, and Everdur (3 per cent Si, 1 per cent Mn) bronze.

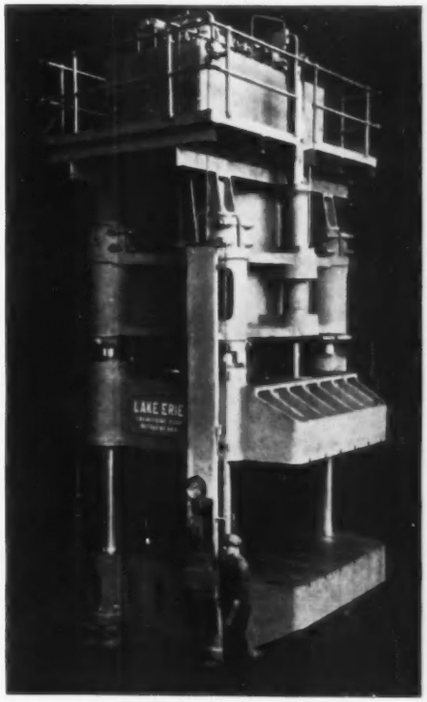
The 10 per cent tin bronze, the manganese-silicon bronze, and the 5 per cent aluminum bronze were markedly improved by adding 3 to 5 per cent of silver to the alloy. The silver addition induces a response to precipitation hardening heat treatment, although some improvement was observed even without special heat treatment.

Approximately 5 per cent of silver added to the wrought eutectic aluminum silicon alloy conferred substantial added hardness at temperatures above the softening temperature of the silver-free alloy. It is expected from the data obtained to date that silver will be found to improve the high-temperature properties of aluminum-rich alloys in general, as well as in the case of the Al-Si alloy mentioned.

Lead-silver soft solders (5 per cent silver) have been found to make satisfactory sweated joints in copper tubing assemblies, and such joints have good properties when tested at elevated temperature for long periods of sustained loading.

Research at the Battelle Memorial Institute on bearings has brought out advantages which a silver-lead alloy (4 to 6 per cent lead) seems to offer when compared with pure silver. Effort is now being made to prepare steel-backed bearings of this alloy by electrodeposition methods.

Research is continuing at Rensselaer Polytechnic Institute on sliding silver



2500 ton capacity hydraulic press, built by the Lake Erie Engineering Corporation for the French Air Ministry, to be used for forming duralumin sections of airplane wings, pontoons and fuselage parts. Press weighs 392,000 lb.; ram is 42 in. diameter; platens are 150 by 89 in. Electrically driven pumps are mounted on the upper deck

contacts. A performance comparison has recently been made between latest model starter motors equiped with copper-graphite and silver-graphite brushes.

A study of temperature-pressure and time relationships in the cold-welding of silver has been completed at Lehigh University. Cold-welding at temperatures as low as 200 deg. C. was observed.

Powerful Televisor Nears Completion

A TELEVISION transmitter, designed to broadcast with improved picture definition, will be put into operation within the next three months by General Electric at Indian Ladder in the Helderberg Hills, 12 miles from Schenectady, N. Y.

Built on top of a 1500-ft. hill with an antenna strung on 100-foot towers, this station will be at least 250 feet higher than the one atop the Empire State building in New York. To the south are higher hills which, with a directional antenna, will tend to prevent the signal from causing any possible interference with stations in New York City. With a power output of 10 kilowatts, the transmitter coverage will be the area comprising Schenectady, Albany, Troy, Amsterdam, and Saratoga.

From an ultra short-wave transmitter on top of the studio building in Schenectady, the images will be relayed over the 12-mile gap on a 1.4 meter band to the main transmitter in the Helderbergs, where they will be broadcast for public reception on a wavelength in the 66-72 megacycle band or on about 4½ meters. The voice accompanying the picture will also be broadcast on the same band, on a frequency immediately adjoining the picture, assuring reception with less interference from static than experienced on the regular broadcast channels.

Finishing Symposium at A.S.T.E. Convention

A symposium on "surface finish"—with proponents of all methods of accurate surface finishing presenting papers on grinding, lapping, diamond boring, honing and "super-finishing" will be a highlight of the 1939 A.S.T.E. convention in Detroit March 14th to 18th. A second symposium, "New Developments and Their Effect on the Tool Engineer", will bring together in one evening session a group of papers on new methods, materials, and equipment.

There will be no day-time technical sessions, so that tool engineers will be free to visit the 1939 Machine and Tool Progress exhibition as well as the numerous industrial plants through which tours have been arranged.

I.A.E. Presents Awards at Annual Meeting

At the seventh annual meeting of the Institute of Aeronautical Sciences, held at the Pupin Physics Laboratories, New York, during the last week in January, awards were presented to A. V. de Forest and Russell C. Newhouse.

Mr. de Forest received the Sylvanus Albert Reed award for the development of a method generally used in the aircraft industry for testing metals magnetically. The Lawrence Sperry award was presented to Mr. Newhouse for the development and first practical application of the terrain clearance indicator.

Leipzig Fair

THE Leipzig Trade Fair, which will hold its next session from March 5th to 13th, 1939, will comprise over 10,000 exhibits of the newest products of thirty-four countries. The spring fair will be the 1981st session of the historic exchange which has been in existence for more than 700 years.

MEETINGS

AMERICAN MANAGEMENT ASSOCIATION—*Ninth annual conference and exposition of packaging, packing and shipping, Hotel Astor, N. Y., March 7-9. American Management Association, 330 W. 42nd St., N. Y.*

AMERICAN SOCIETY OF TOOL ENGINEERS—*Annual meeting and machinery and tool progress exposition, Detroit, Mich., March 14-18, Ford R. Lamb, executive secretary, 2567 West Grand Blvd., Detroit, Mich.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*National aeronautic meeting, Washington, D. C., March 16-17. World Automotive Engineering Congress, Hotel Pennsylvania, N. Y., May 22-28, Hotel Statler, Detroit, May 31-June 8, Hotel Fairmont, San Francisco, Cal., June 6-8. John A. C. Warner, secretary, 29 W. 39th St., N. Y.*

AMERICAN FOUNDRYMEN'S ASSOCIATION—*Annual convention, Cincinnati, Ohio, May 15-18, C. E. Hoyt, executive vice-president, 222 West Adams St., Chicago, Ill.*

AMERICAN IRON AND STEEL INSTITUTE—*General meeting, Hotel Waldorf-Astoria, N. Y., May 25. Walter S. Tower, executive secretary, 350 Fifth Ave., N. Y.*

AMERICAN ELECTRO-PLATERS' SOCIETY—*International convention, Asbury Park, N. J., June 19-22. W. J. R. Kennedy, executive secretary, 90 Maynard St., Springfield, Mass.*

AMERICAN SOCIETY FOR TESTING MATERIALS—*Annual meeting and exposition, Chalfonte-Haddon Hall, Atlantic City, N. J., June 26-30. R. E. Hess, assistant secretary, 260 S. Broad St., Phila., Pa.*

Typical section of extensive conveyor system installed in the new Revere Brass Mill at Rome, N. Y. The metal travels on the gravity conveyor to and from run-down mill, annealing furnaces, pickling and cleaning units and storage reservoir. Metal can be diverted from one section of conveyor to another according to the nature of the next operation required

Corrosion Tests on Painted Steel Sheet

FACTORS affecting the protective value of paints for steel and galvanized surfaces are being studied at the National Bureau of Standards, using accelerated laboratory corrosion tests. When steel is used in the form of light-gage sheet, protection is a matter requiring serious consideration, particularly in inaccessible locations, such as the interior of walls. An important part of the present investigation is a laboratory study of the conditions affecting the durability of paint films on steel and galvanized surfaces under conditions somewhat similar to those which might be encountered in service. Special attention is being given to the severity of corrosion resulting from condensed moisture, and painted steel and galvanized metal panels are being tested in the accelerated weathering apparatus, salt spray, and in a condensation corrosion chamber, and similar panels are also exposed outdoors on the roof of the Chemistry building. Numerous pre-treatment solutions for both galvanized metal and plain steel, with about 60 priming paints, are included in the investigation.

An account of this work is given in a new Report on Building Materials and Structures, BMS8, now available from the Superintendent of Documents, Government Printing Office, Washington, D.C.

Do You Know That—

WOVEN GLASS fiber gaskets that are soft, pliable, resilient and resistant to practically all acids except hydrofluoric, are now available. (5)

A NEW TELEPHONE INSTRUMENT, powered solely by the speaker's voice, enables the user to call any of five other stations. (6)

A LUBRICATION METHOD employing colloidal graphite suspended in kerosene, is now being used on conveyor chains operating in high temperature zones. (7)

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr. wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.*)

No. 10

QUESTION: What methods have been found effective in stimulating the rank and file in the invention, development or design departments to invent new or better products?

ANSWER: Since the personnel of these departments are already being paid salaries for the work of inventing and designing, it is unusual to pay them direct incentives for their inventions. However, several companies have found that it pays well to offer indirect incentives as rewards for extra effort. One concern which manufactures business machines has this set-up for development work:

At the top is what is known as a "future demands department" which through research and careful study of the market and probable future trends undertakes to determine the types of equipment which the company should produce in the future. This department's findings and recommendations are submitted to a "future demands committee," which passes on them and determines definitely along what lines the products should be developed.

The committee's findings are referred to one of the regular inventors, of which the company has several—all highly paid men. It is the job of the inventor to develop the necessary mechanism for accomplishing the desired results. About 95 per cent of the work of the inventors is along these lines, although, of course, they also frequently make suggestions for improvement in the product outside of their regular assignments.

Each inventor has as assistants two to five of the best designers on the staff, who work out the detailed mechanisms under the close supervision of the chief inventors. These designers are in reality assistant inventors and are paid accordingly. When, as often happens, these assistant inventors in the regular course of their work contribute important suggestions showing ingenious original thought they are usually included as joint inventors. The immediate value of this to the co-inventor is chiefly in added prestige although, of course, consistent merit of this sort is rewarded by increased salary and ultimately by promotion to the rank of chief inventor.

The bait of increased prestige and ultimate promotion to a job where they can be inventors independent of any supervision has proved to be a greater incentive to independent thought than direct money rewards. Most of the best inventors come from the ranks of the assistant inventors.

Below the assistant inventors is what is called the "invention designing room" which makes the detail drawings for models after the general layout of an invention has been made by the inventors and their assistants.

From the draftsmen in this room, the assistant inventors are chosen, based largely upon the original inventive thought demonstrated by them. The draftsmen, being in such close contact with the development work are in excellent position to make suggestions in design which are well worth while.

The policy of promoting original thinkers from the rank-and-file draftsmen, first to assistant inventors and finally to full-fledged inventors has resulted in a steady flow of excellent ideas from that source. The able and ambitious draftsmen covet not only the larger earnings that go with the higher jobs, but also the prestige that accrues both within and outside of the company.

A leading company, in another branch of industry, which has highly organized research and development departments, also believes that it is undesirable to give direct bonuses for suggestions from those whose regular work is to assist in making inventions. Its experience was that to do so encouraged abnormal secrecy, based on jealousy, and this seriously impaired the spirit of team work which is absolutely essential in such departments.

To encourage suggestions from this source, the company is quick to reward unusually good work among its inventors, draftsmen and designers with salary increases. This indirectly brings cash bonuses inasmuch as the company pays wage dividends and makes distributions of the company's stock in proportion to the amount of salary.

This method, which has been in effect for several years has resulted in co-operation among those in a position to make worthwhile suggestions and a consequent free and copious flow of good ideas from the rank and file.

New Materials and Parts

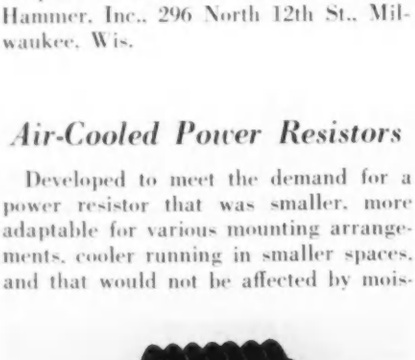
Motor-Operated Brake

Designed especially for applications where positive, quick, "cushioned" braking is required for stopping or holding a load. An a.c. torque motor, operating through a simple anti-friction ball jack,

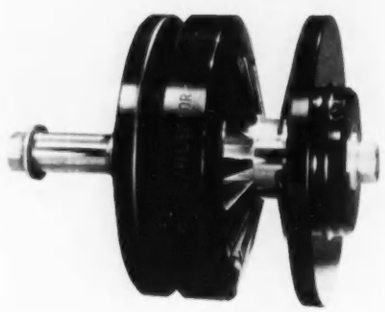
releases the brake. When the brake is fully released, the torque motor is stalled across the line. When the circuit is opened, the heavy, helical torque spring sets the brake. A slight flywheel action of the rotor provides smooth, cushioned braking. Brake is available in five sizes, providing maximum torque ratings of 160, 400, 800, 1,600 and 3,200 lb.ft. on intermittent duty. Continuous duty ratings are slightly lower. Available for all commercial frequencies and voltages. Descriptive Bulletin 508 available. Cutler-Hammer, Inc., 296 North 12th St., Milwaukee, Wis.

Air-Cooled Power Resistors

Developed to meet the demand for a power resistor that was smaller, more adaptable for various mounting arrangements, cooler running in smaller spaces, and that would not be affected by moisture and atmospheric conditions. Type CA resistors are manufactured in standard size units measuring $1\frac{3}{4}$ in. long by $1\frac{1}{8}$ in. O.D. Both ends of the bobbin are tapped and threaded for a 6/32 screw. Available for upright or horizontal mounting or center tapped or series connected for higher wattage use. Mountings are not furnished with the resistor. Rated at 50 watts, accuracy 3 per cent, resistance range 10 to 50,000 ohms. Descriptive leaflet available. Precision Resistor Co., 332 Badger Ave., Newark, N. J.



Variable-Speed Pulley



Improved "Speedmaster" pulley molded of solid high impact strength phenolic plastic, trued and balanced before final assembly. An improved pressure lubricated bronze sleeve allows the splined center sheave member to operate freely, regardless of load or speed. Advantages claimed by the manufacturer for the Speedmaster pulley are: a six-to-one up to a forty-to-one ratio of infinitely variable speed, the use of standard V-belts, and long belt and pulley life because of the molded plastic work faces. Unit available in two sizes, a $3\frac{1}{2}$-in. diam. size for drives up to $\frac{1}{2}$ hp. capacity, and a $6\frac{1}{2}$-in. diam. size for drives up to 3 hp. capacity. Continental Machine Specialties, Inc., Minneapolis, Minn.

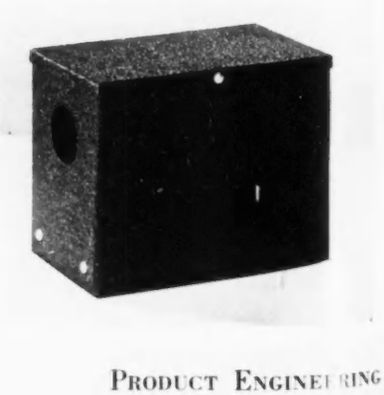
Streamlined Counters

An entire new series of counting machines, known as Series H Productimeters, including stroke and revolution counters in 20 variations to fit any industrial application. Counters have dust-

tight metal covers with dark gray crackle finish, and require no attention or maintenance as all shafts run on oilless bearings. Louvered windows and all metal number wheels with large black figures on white background make easy reading of the count at some distance from the counter. Series H Productimeters are available in stroke or rotary models; non-reset, wing nut reset, or tumbler lock reset; operating levers on left or right; shaft extensions on left or right, or both ends; five or six figures; rotation clockwise or counter clockwise. Durant Mfg. Co., Milwaukee, Wis., and Providence, R. I.

Light Relay

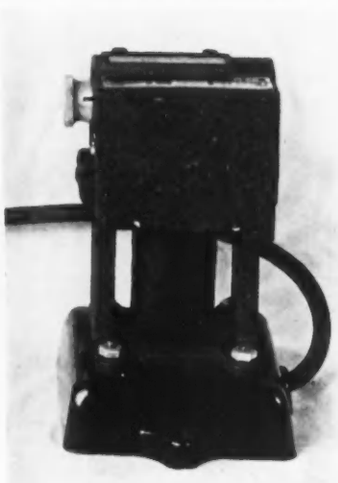
Compact, inexpensive light switch utilizing a conventional emissive type photoelectric cell, feeding one stage of amplification. The amplifier is a standard radio tube, the output of the tube operating a telephone type relay to insure speed of operation and maximum sensitivity to small light changes. Relay contacts are rated at 75 watts, arranged for both a make and a break circuit. Unit is 6 in. long, $4\frac{1}{2}$ in. high and $3\frac{1}{2}$ in. wide. A companion light source is housed in an identical container. According to manufacturer, when operating under ideal con-



ditions, the beam of light between the light source and the photo-electric unit may extend up to 35 ft. Typical applications of the unit include controlling conveyors, starting and stopping motors upon light beam interception, and many other applications where the frictionless interception of a beam of light is to close or open an electrical circuit to initiate desired actuation. Electronic Control Corp., 2667 E. Grand Blvd., Detroit, Mich.

Photoelectric Counter

Known as Type PC-3, this counting equipment has been developed to meet the need for accurate counting of high-speed machinery. Equipment consists of photoelectric cell relay, light source, power supply and counter. The polarized plug connections for cables permit the photoelectric cell amplifier and relay to be readily removed for check and replacement. Equipment is guaranteed to be accurate to 600 counts per minute



or 36,000 counts per hour. Estimated tube life is 7,000 to 10,000 hr. Lipman Engineering Co., 415 Van Braam St., Pittsburgh, Pa.

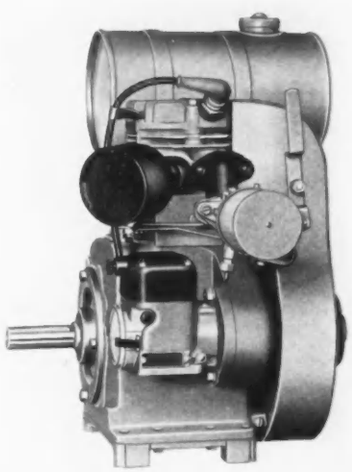
Molding Compounds

Two new asbestos-filled molding materials, Durez 38–443 and Durez 38–646. The former was formulated specifically to meet Underwriters' specifications of withstanding 200 deg. C. for 72 hours. Impact strength is 0.23 (ASTM), compressive strength 28,000 (ASTM), heat resistance 490 deg. F., specific gravity 1.80. Durez 38–646 compound is claimed to have an exceptionally low specific gravity for asbestos-filled molding compounds. Heat resistance is 500 deg. F., impact strength 0.19 (ASTM), flexural strength 9,000 (ASTM), compressive strength 27,000 (ASTM). General Plastics, Inc., North Tonawanda, N. Y.

Comparator

An internal and external comparator with adjustable contact pressure, Model 36B-B for measuring I.D. of small holes and O.D. or thickness to less than 0.0001 in. Three basic methods of measurement are possible: two adjustment contact, triangular three point adjustment and direct diameter three point contact. Plates are interchangeable. Adjustment screws are located in the front of the base. Contact jaws are made to suit requirements for inside diameters between 0.375 and 3.375 in. or outside sizes up to 2.625 in. and are interchangeable for different sized holes or outside measurements. Federal Products Corp., 1144 Eddy St., Providence, R. I.

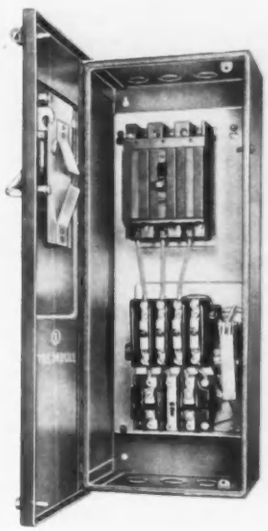
Marine Engines



Inboard air-cooled marine engines in ten models ranging from 1 to 35 hp. for use in auxiliary or propulsion service. These are standard Wisconsin engine models modified to suit marine service. They have high tension magneto with impulse coupling mounted on the outside for ready access, special marine carburetion, special nickel-chrome valve seat inserts, Timken roller bearings. They can be equipped with reduction gearing, reverse gears and with clutch. No thrust bearing is required between the engine and propeller shaft. Combination air cleaner and flame arrester is furnished with all models. A single-cylinder, 1-hp. motor with stub shaft is illustrated. Descriptive leaflet available. Wisconsin Motor Corp., Milwaukee, Wis.

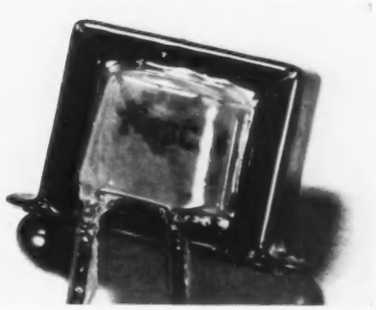
Combination Magnetic and Circuit Breaker

An addition of combination magnetic starters and circuit breakers to their line of industrial control. Device measures $1\frac{1}{8}$ in. wide by $1\frac{3}{4}$ in. high. Available in the range of 0–25 hp. control at 110–550 volts a.c. The Trumbull Electric Mfg. Co., Plainville, Conn.



Protected Transformer

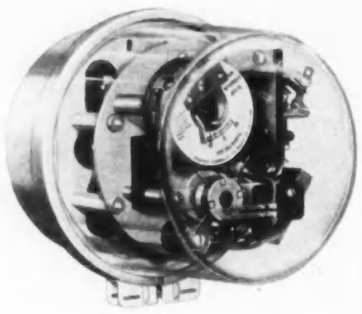
Known as the "Tropex" transformer, protected by a complete covering of a special transparent and elastic compound which is highly resistant to adverse climatic conditions, especially excessive



moisture. The Tropex finish is said to be practically odorless, neat appearing and clean and easy to handle. Bulletin available. Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago, Ill.

Microtrol Relay

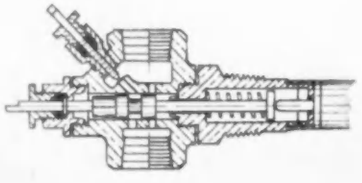
A completely automatic, ultra-sensitive controller, entirely self-contained, and housed in a weatherproof case. Combining the Sensitrol relay Model 705 and the power relay Model 712, the Microtrol relay is designed for an operating interval in which the power relay will open and close once each 4 sec. The relay will remain closed approximately 3 sec. and open 1 sec. These time intervals can be changed on special order, so that the device will close once each 15 sec., once each minute, or remain

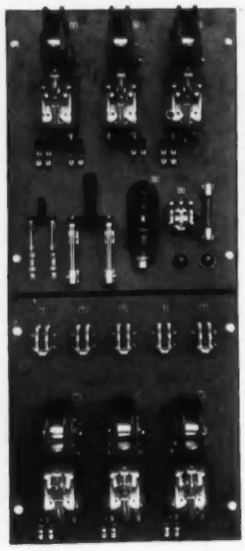


closed continuously until conditions return to normal. Available in the same ranges as the Sensitrol relay Model 705, the Microtol relay Model 726 is intended for use on 120 volt, 60 cycle circuits. For special requirements the relay can be supplied for any commercial frequency, at voltage ranges from 12 to 250 volts. Weston Electrical Instrument Corp., Newark, N. J.

Cooling Water Control

Designated as Type TR-40, this regulator was designed especially for use on cooling water jackets of internal combustion engines and compressors. Control consists of a piston valve operated by a liquid expansion thermostat to throttle the flow of cooling water as required to maintain a constant temperature. The valve is provided with a bleeder port adjustable from the outside, which allows a small amount of cooling water to flow at all times. A safety device in the form of a fusible plug prevents damage to the engine in the event of thermostat failure. Control is available in sizes from $^{3}/_{8}$ to 1 in. sizes. Sarco Co., Inc., 183 Madison Ave., New York, N. Y.





Motor Starter

Complete line of starters and controllers using the new Neo-Time acceleration, designed for automatically controlling the acceleration of either a.c. or d.c. motors. The Neo-Time principle is based on the time required to charge a condenser to a predetermined voltage. When this voltage is reached, the condenser discharges through an industrial type neon tube to cause the first acceleration contactor to close. When this contactor closes, the same timing circuit is re-energized to close the next accelerating contactor, and this operation is repeated until the motor is operating on full line voltage. An adjustable resistor is placed in the condenser-charging circuit to permit a convenient means of varying the time. Illustration shows a 75 hp., 230 volt, d.c., Neo-Time starter. It provides a total acceleration time varying from 15 sec. minimum to about 160 sec. maximum. Adjustment of the dial varies the time between these limits and the use of resistors of different values given a longer range of time or a shorter range of time as desired. The Electric Controller & Mfg. Co., 2682 E. 79th St., Cleveland, Ohio.

Colalloy

Colalloy is an alloy of manganese, magnesium, silicon, aluminum (copper and chromium where necessary), and some lesser proportions of other metals. Depending upon the use for which it is intended, it is made up in a variety of sizes, hardnesses, strengths, endurance limits and other physical and mechanical properties. For example, ultimate strength may range from 12,000 to 61,000 lb. per sq. in., yield strength from 3,900 to 4,900, Brinell hardness from 20 to 110, Melting temperature is 1,210 deg. F. and thermal conductivity at 100 deg. C. in c.g.s. units ranges from 0.27 to 0.51. The complete range covers more than 30 alloys each suited to a particular purpose. They will not rust, are nontoxic and have high thermal factors, and will not taint or damage the most delicate foods. Material is made in all gages, sizes and forms of sheets, strips, flats, plates, seamless tubing, fittings, structural shapes, bolts, nuts, etc. Bulletin available. Colonial Alloys Co., E. Somerset, Trenton Ave. & Martha St., Philadelphia, Pa.

Pressure Gage

A power type pressure gage suitable for the measurement of extremely high pressures and claimed to be accurate to one-tenth of one per cent of the reading. It provides accurate pressure readings on an indicating scale and may also transmit these readings to indicators and recorders located at distant points. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

Triple Seal

For bearing protection against lubricant leakage, dirt, dust and moisture. Seal consists of two split piston rings on each side of the housing and grooved on the outside diameter to form a labyrinth seal with the two end bores of the housing. Each ring has an inward tension that enables it to turn with the shaft. If any lubricant should pass the first seal, it is returned into the housing through a hole located in the center groove of the bottom half of the housing. The triple seal is made for the complete

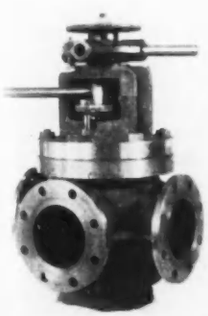
range of standard shaft sizes, and is designed for split housings which are machined to allow axial freedom of the bearing. SKF Industries, Inc., Front St. & Erie Ave., Philadelphia, Pa.

Automatic Timer

Designed for low cost, built-in use, the new Series 50 Walser automatic timer is equipped with silver contacts for the control of 15 amp. of alternating current at 125 volts. Switch is normally open and stock timing ranges of 15, 30 and 60 min. are available. Timer is basically and dimensionally the same as the Series 75CH, introduced two years ago, except for the operating method and the newly designed switch mechanism. Model 503 illustrated. Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.

Lift-Plug Valve

Developed for use on air, water, oil, and gas services at working pressures up to 150 lb., and temperatures below 400 deg. F. Valves are available in sizes from 1¼ to 3½ in. and have three ports with three different styles of port arrangement. Direction of flow is changed by a quarter-turn of the operating lever. The powerful leverage and screw of the lift-plug feature assures ease of operation and permits the plug to be sealed in the body in either of its two extreme positions of travel, or in a mid-position, so that all ports are closed. Bulletin available. Homestead Valve Mfg. Co., Inc., Coraopolis, Pa.

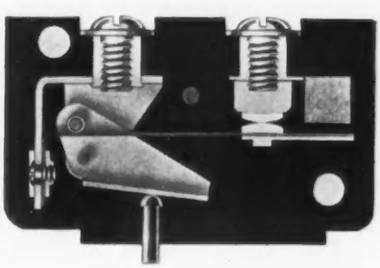


Sealing Compound

A flexible, non-hardening gasket and joint sealing compound, known as "Titeseal." It is non-solvent and claimed to be unaffected by heat, cold or extreme fluctuations in temperature. May be used as a gasket where tolerance permits, with gaskets, as a theaded joint dressing, as a filler with packings, as a special insulation material, and as a rust and corrosion preventive. Radiator Specialty Co., Charlotte, N. C.

Snap Switch

A compact, low-operating pressure, short-travel type snap switch. The basic consideration in the design of the switch was to accomplish a quick make or break with a wide air gap, and still retain the advantages of highly sensitive, short-movement operation. Switch measures $1\frac{5}{8}$ x $1\frac{3}{32}$ x $\frac{13}{16}$ in. and operates on d.c. or a.c. The operating force required to open or close the switch is as low as 3 oz., but types are available with operating pressures as great as 12½ oz. Plunger movement may be as short as 0.005 in. or as long as 0.014 in. The switch illustrated is the single pole, normally closed type, but it is also made in normally opened types, single-pole,



double throw types, and other variations. Descriptive circular available. McDonnell & Miller Co., Wrigley Bldg., Chicago, Ill.

Hydraulic Transmission

A hydraulic variable-speed transmission which is claimed to give precisely the desired speed regardless of changes in load, voltage, frequency, speed of drive, oil temperature or running fits. The drive consists of a standard Oilgear fluid power transmission with micro servo-motor stroke control cylinder to adjust the pump stroke to give exactly the required hydraulic motor speed. Oil is admitted to this cylinder by a pilot valve, actuated by a small differential unit which continuously compares the hydraulic motor speed with time, or with the speed of any desired master unit. Preset speeds are held within plus or minus

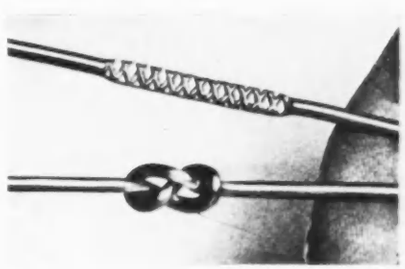
¼ per cent of rated speed when load changes are gradual. Available in two types, the disk type for general commercial applications, and the pendulum type which is required only when the frequency error in the power supply is greater than the tolerable error in the hydraulic motor speed. Bulletin 15800 available. The Oilgear Co., 1301–1417 W. Bruce St., Milwaukee, Wis.

Zinc Pre-Finish Compound

For treating the surfaces of zinc, zinc-coated and galvanized products before finishing. By dipping or wiping with a solution of the compound, called Zinsol, the compound causes the formation of an alloy, consisting of zinc and another metal, to form on the surface. This alloy is chemically inert to moisture, the atmosphere, and organic finishes generally, so that it forms a stable foundation for any desired finish, such as lacquer, enamel, paint or varnish. Maas & Waldstein Co., Newark, N. J.

Magnet Wire

Insulated with a synthetic resin of the polyvinyl acetal type, eliminating the need for protective coatings. "Formex" wire is said to have electrical properties as good as those of ordinary enameled wires, and according to tests is higher in resistance to abrasion and to common treating solvents. When severely twisted and then subjected to a temperature of 125 deg. C. for one hour ordinary enameled wire cracks whereas Formex is not affected. Can be utilized in nearly all applications to replace enameled wire



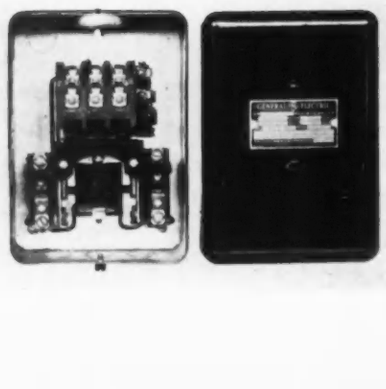
and in many applications to replace enamel-cotton, enamel-paper or other fabric-covered wires. General Electric Co., Schenectady, N. Y.

Centrifugal "Motorpump"

Particularly suitable for compact installations, having a depth of submergence of only 6¼ in. Designated as No. 205, it is identical in performance, capacity and electrical characteristics to their No. 206 "Motorpump." It is available with a number of different motor types to meet the requirements of most electrical installations. Pump is fitted with a fully inclosed motor and grease-sealed ball bearings. The stainless steel shaft is integral with the motor and the aluminum bronze impeller is the open or non-clogging type. Hydraulically balanced, the impeller is designed to allow abrasives to be discharged without excessive wear within the housing. The unit is suitable for supplying coolant for machine tools and light machinery where dirt or abrasives may be present in the liquid and where a moderate volume of flow is desired at a low head. Brown & Sharpe Mfg. Co., Providence, R. I.

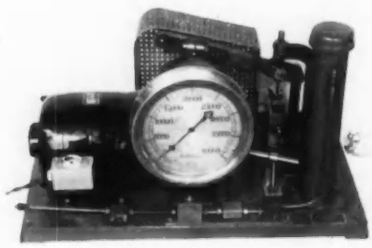
Small Magnetic Switch

A new a.c. magnetic switch, CR7006-D51, developed for full-voltage starting of single-, two- and three-phase motors. Its principal features, in addition to its small physical dimensions, are its conservative electrical design, long mechanical life, and low maintenance costs. Basically, the switch consists of a line contactor, with interlock to provide undervoltage protection, and two isothermic temperature overload relays to protect the motor against over-heating. These elements are mounted in a general-purpose sheet-steel inclosing case. The open-type switch is furnished with a rigid mounting plate to permit easy mounting on either an insulating or a conducting panel. General Electric Co., Schenectady, N. Y.



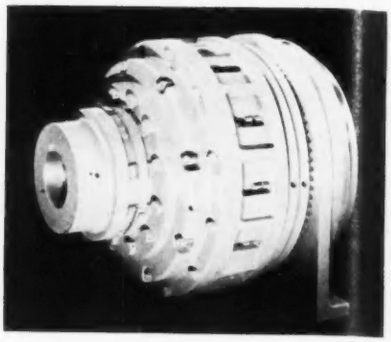
Hydraulic Pump

Motor-driven hydraulic pump capable of developing pressures up to 30,000 lb. per sq. in. Also a dead weight gage for measuring the pressure developed. Pump is used for creating high test pressures for determining bursting strength of cylinders and spheres, for operating high-pressure and hydraulic intensifiers, and for carrying out experiments to determine the effect of high pressures and sudden release on various materials. American Instrument Co., Silver Spring, Md.



Valve Positioner

For use on diaphragm control valves to overcome the effect of friction in the valve stem and top. Recommended for use on air-operated control installations requiring close control or where there is considerable process lag. Valve positioner is claimed to assure a proportionate valve stem travel for even the slightest change in the pressure of the air from the controller. The Bristol Co., Waterbury, Conn.

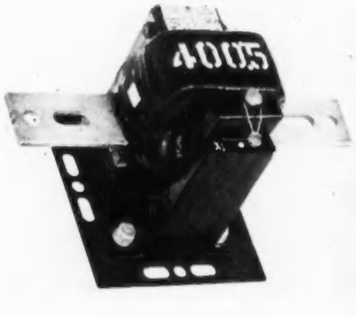


Magnetic Clutch-Brake

Combination clutch and brake. Style "FFP," providing friction and positive clutch, with brake. It can be engaged at normal motor speeds, and is claimed to provide smooth acceleration, positive non-creep running and split-second, disk brake stopping. Simplified control, consisting of pushbutton stations for starting, running and stopping can be conveniently located to provide easy, instant control. Clutch-brake combination is particularly adaptable as a safety device on positive drives. Stearns Magnetic Mfg. Co., Milwaukee, Wis.

Current Transformer

Type JL-1 indoor current transformer, designed to combine the advantages of small size with high accuracy for metering on low voltage circuits. Rated for 600 volts, available in three current ratings, 200/5, 400/5 and 600/5 amp. General Electric Co., Schenectady, N. Y.



Tool Steel

An oil-hardening, non-deforming tool steel, known as "Ketos," for use where toughness, non-warping and safety in hardening are first considerations. Its widest application is for blanking, trimming and forming dies of intricate design. Freedom from shrinking and warping combined with ability to resist wear, makes it particularly suitable for gages, taps, master tools, blanking dies and plastics molding dies. Folder TS 201 available. Crucible Steel Co. of America, 537 Broome St., New York, N. Y.

Manufacturers' Publications

BABBITT METAL—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. "Glyco Babbitt," 8 pages, 8½x11 in. Data on the physical structure of Glyco babbitt and recommended applications for the various grades carried in Ryerson stock.

BALL AND ROLLER BEARINGS—The Ball and Roller Bearing Co., Danbury, Conn. Catalog 15, 78 pages, loose-leaf, 6x9 in. Covering their line of ball and roller thrust bearings with illustrations and specification tables, including radial roller bearings and journal roller bearings. Also a table of allowable loads on chrome steel balls.

CONTROLLERS—The Bristol Co., Waterbury, Conn. Bulletin 523. Complete data on their Model 6089V single-cam cycle controller are presented. Also describes their three-way leakless pilot valves with which the controllers are equipped.

CYLINDERS—Hanna Engineering Works, 1765 Elston Ave., Chicago, Ill. Bulletin 228, 28 pages, 8½x11 in. Illustrations, dimensional drawings and complete specifications covering the Hanna line of cushioned and non-cushioned cylinders.

ELECTRICAL DEVELOPMENTS—General Electric Co., Schenectady, N. Y. Booklet GED-766, 56 pages, 9x12 in. A well-illustrated, interesting presentation of G. E. "Electrical Development of 1938."

ELECTRICAL EQUIPMENT—G-M Laboratories, Inc., 1733 Belmont Ave., Chicago, Ill. "G-M Comments," 8 pages, 8½x11 in. Information on their galvanometers, phototubes, power supply units, and rheostats. Also includes two new G-M instruments and a new series of self-generating photoelectric cells.

ELECTRIC PRODUCTS — Bulldog Electric Products Co., Detroit, Mich. Catalog 391, 86 pages, 8½x10 in. Their January 1939 catalog covering their line of electric products. Details on their new rocker type safety switches and panelboards are included.

FILTERS—Cuno Engineering Corp., Meriden, Conn. "80 Ways to Make More Money," 24 pages, 8½x11 in. Presenting 80 actual cases of Cuno continuously cleanable filters at work in industry, indexed in three divisions to cover the process, power and heavy industries. One section is devoted to the design engineer who works in all fields.

GEARMOTORS—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Leaflet 2203-B. Describing their compact, self-contained gearmotor speed reducers for efficient low-speed operation. Line drawings, installation photographs showing typical gearmotor applications, and a table of ratings and speeds with 1,750 r.p.m. motors, are included.

GEARED DRIVES — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet B-2159, 32 pages, 8½x11 in. A profusely illustrated presentation, explaining the uses, adaptations and developments of all types of geared drives, with special emphasis on the quarry, textile, pulp and paper, coal, steel and petroleum industries, and also other industries utilizing electrical power.

GEARMOTORS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Descriptive Data 3620, 8 pages, 8½x11 in. Westinghouse gearmotors, self-contained drives consisting of a high-speed motor and necessary speed reducing unit, are illustrated and discussed.

HOSE—Chicago Metal Hose Corp., Maywood, Ill. Catalog G-14, 40 pages, 8½x11 in. Contains illustrations and engineering data on Rex-Weld corrugated metal hose, Rex-Tube asbestos packed hose and other types, and couplings recommended for each type. Featured in the "New Products" section are their Avioflex hose, RW-89 diesel exhaust hose, and stainless steel bellows.

HOSE—The DeVilbiss Co., Toledo, Ohio. Catalog HD, 24 pages, 8½x11 in. Containing information on their complete line of hose with specifications for each type covered, together with information for proper selection. The introductory section traces the product from the baled crude rubber, through the DeVilbiss hose factory and testing laboratory, to its various finished forms. Another section is devoted to the complete line of hose connections, valves, couplings and adapters manufactured by the company.

LINESTARTERS — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Price List 11-200. Illustrating and describing their De-ion non-reversing linestarters with built-in control-circuit transformers, designed for applications where a low voltage control circuit is desired.

MAGNETIC DISK BRAKE—Stearns Magnetic Mfg. Co., Milwaukee, Wis. Bulletin 650. Describing their Style DM magnetic disk brake.

MEEHANITE—Meehanite Metal Corp., Vandergrift Bldg., Pittsburgh, Pa. Booklet Form 100, 8 pages, 8½x11. Describes and illustrates various adaptations of Meehanite to pumps subject to severe service requirements. Results of recent cavitation tests on different types of Meehanite are included.

MOTORS—The Louis Allis Co., Milwaukee, Wis. Bulletin 610, 8 pages, 8½x11 in. "General Information on NEMA Standards and Definitions," including suggestions for the proper selection of motors, types of drives, various types of protected motors and their definitions. Also information regarding service factors, rated loads, torques, etc.

MOTORS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. "Simple Facts About Synchronous Motors," 12 pages, 8½x11 in. Booklet B-2164. Descriptive data on synchronous motors presented in language the layman can understand, details on proper selection, applications, and advantages.

NICKEL—Development and Research Div., The International Nickel Co., 67 Wall St., New York, N. Y. Bulletin T-15, "Engineering Properties of Nickel," 20 pages, 8½x11 in. Containing extensive tabulated data on the mechanical properties and physical constants of nickel. A section is devoted to the more commonly used special nickel alloys.

NICKEL ALLOY STEELS—The International Nickel Co., Inc., 67 Wall St., New York, N. Y. "Iron-Nickel Alloys for Magnetic Purposes," Section IV, No. 2, of the Nickel Alloy Steels Data Book. Describes these permanent magnet alloys and also the high permeability alloys containing nickel.

OIL PUMPS—DeLaval Steam Turbine Co., Trenton, N. J. Catalog L-31, 8 pages, 8½x11 in. Illustrations and descriptive details covering their rotary displacement pumps for handling fuel and crude oil, lubricating oils and hydraulic oils.

PACKING—Ames Bag Machine Co., 509 Advance Bldg., Cleveland, Ohio. "Short Cuts in Shipping." Setting forth in condensed form the results of the experiences in this field of the Ames Bag Machine Company, pioneers in the manufacture of cotton bags for packing and shipping odd-size machine parts and small articles.

PERMANENT MAGNETS—The Indiana Steel Products Co., Valparaiso, Ind. "Permanent Magnet Manual No. 1," 32 pages, 8½x11 in. A practical description of application and control of magnetic energy as supplied by permanent magnets. Sections cover factors governing the use of magnetic energy, permanent magnetic materials, maximum efficiency, and the design, manufacture and advantages of "Ispco" magnets. A section of typical questions and answers about permanent magnets is included.

POTENTIOMETER CONTROLLERS—The Foxboro Co., Foxboro, Mass. Bulletin 202-2, 24 pages, 8½x11 in. Illustrations and complete descriptive details concerning the outstanding features of their potentiometer controllers for governing temperatures in making iron and steel, glass, ceramics and chemicals. Sections are also devoted to throttling potentiometer controllers, electric resistance thermometer automatic controllers, potentiometer control pyrometers, and resistance thermometer controllers. Illustrations of installations of the controllers are included.

TEMPERATURE CONTROLLERS — Burling Instrument Co., 241 Springfield Ave., Newark, N. J. "A Message About a Heat Dictator." Illustrations and brief specifications on a number of their temperature control instruments.

THERMOMETERS—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. Catalog 1170, 16 pages, 8½x11 in. Descriptive details and illustrations of their TAG dial-indicating thermometers, together with details on accessory equipment.

VALVES—The Berkeley Engineering Co., 1381 East 17th St., Cleveland, Ohio. Bulletin, 4 pages, 8½x11 in. Illustrating and describing their floating disk valves for the control of air or liquid pressures to 250 lb.

Books and Bulletins

Steel and Its Heat-Treatment Vol. II

D. K. Bullens *and the metallurgical staff of the Battelle Memorial Institute.—Fourth edition, 198 illustrations, 491 pages, 6x9 in. Brown clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $5.00.*

Volume II deals with the properties of the simple engineering steels, both carbon and alloy; steels of complex composition; and the special purpose steels. Much of the discussion not only concerns, as the title suggests, the heat-treatments of various steels but also analyzes the reasons for introducing the alloying elements with their characteristics, and details the special properties they confer upon steel. For the presentation of collated data covering many steels, charts and diagrams are used to show the influence of basic factors.

This second volume of the revision of earlier editions is a valuable guide towards making an intelligent choice among the compositions of and treatments for the special steels that are now available.

The Engineers' Manual

Ralph G. Hudson.—*Second Edition, 340 pages, 5x8 in. Flexible covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $2.75.*

A compilation of engineering formulas including mathematics, mechanics, hydraulics, heat and electricity, presented in a form most suitable for ready reference. Although each formula is preceded by a statement explaining its application, practically none of the formulas is derived although the sequence of formulas usually follows the order of their derivation.

This new second edition contains revisions and extensions of all tables of physical constants, new steam tables and recomputations of all conversion factors affected by the latest definition of the British thermal unit, together with many additions throughout the book.

Typical of the sections, that on mathematics includes practically all of the formulas for the solution of algebraic equations, trigonometry, mensuration, analytic geometry, differential and integral calculus. For this last a table of 214 integrals is included. The section on mechanics covers kinematics, relations of mass and space. Under kinematics are included equations for force, energy and power. Riveted joints, beams, columns and shafts are presented together with tables of properties of standard rolled shapes. Hydraulics, heat and electricity are treated in similar detail.

A section on mathematical tables includes the usual logarithms and trigonometric functions in addition to which are tables on orifice and weir coefficients, of friction factors, steam tables, magnetic curves of iron and steel and similar tables. A table of conversion factors covering 14 pages is an outstanding feature of the book.

Fractional Horsepower A.C. Motors

H. H. Jones. *189 pages, 5x7½ in. Blue clothboard covers. Published by the Chemical Publishing Co., 148 Lafayette St., New York, N. Y. Price $3.00.*

Working principles of fractional-horsepower a.c. motors of various types are described in simple, non-technical style, and no advanced mathematical knowledge is required for solution of the various formulas. Practical details of construction, coil winding, testing and repairs are included, along with a chapter on silencing and suppressing of radiated interference.

Motor types discussed are universal, repulsion-induction, synchronous, eddy-current. Chapters on each include data on operation, stator design, winding calculations, efficiency, starting, torque and applications.

Design of Industrial Exhaust Systems

John L. Alden. *220 pages, 5½x8½ in. Blue clothboard covers. Published by The Industrial Press, 148 Lafayette St., New York, N. Y. Price $3.00.*

This book covers the theory of the flow of fluids and then goes into the design of hoods, ducts and pipes, the operation of dust separators, low pressure conveyors, exhaust fans and structural details in the layout of ventilating systems. The data on exhaust fans concerns primarily their applications and operating characteristics.

In his presentation of the subject of fluid flow, the author has aimed to gather the widely scattered information and data which has appeared in different publications but which is no longer readily accessible. This material has been selected and abridged and presented in a form to make it most useful to the designer.

In the chapter on hood forms, the author first covers the theory of operation, develops the equations for typical hood contours and then shows the designs of some typical exhaust hoods such as used on woodworking saws, shapers, planers, sanders and hoods for metal-working abrasive processes. Hoods for canopies over tanks are included.

Theory and Applications of Electron Tubes

Herbert J. Reich.—*670 pages, 6¼x9¼ in. Blue clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $5.00.*

Although written primarily as a text-book for college students, this book should be of considerable value to engineers for reference, since the basic principles presented are applicable to industrial electronics, power control and electrical measurements as well as to radio engineering. No attempt has been made to discuss all possible applications of tubes to special problems; the aim has been rather to cover basic principles and typical applications. Equivalent-circuit and graphical methods of analysis are stressed throughout. The book is completely cross-indexed and has an extensive bibliography at the end of each chapter.

• • •

Industrial Instruments and Changing Technology

George Perazich, Herbert Schimmel and Benjamin Rosenberg—*Works Progress Administration, National Research Project, Report No. M-1. 148 pages, 7x10 in. Published by the Works Progress Administration, Publication Section, Division of Information, Washington, D. C.*

This report presents the history, function and economic effects of measuring, recording and controlling devices in industry. It was prepared as one of the reports of the National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques. The field data were collected in cooperation with the National Bureau of Economic Research.

Methods and Equipment for Testing Safety Glass

Ray B. Crepps and C. S. Sprague—*Research Series No. 61, 15 pages, 6x9 in. Published by Purdue University, Lafayette, Ind.*

These tests were designed to indicate the mechanical, chemical and optical characteristics of the laminated combination of glass and plastic material. Although the information presented pertains to the testing of safety glass, in many cases the equipment and methods used may be readily adapted for testing other materials of sheet form.

Magnet Coils

Magnetic Pull and Spool Construction

GRAHAM LEE MOSES
Westinghouse Electric & Manufacturing Company

MAGNET COILS have for their primary purpose the production of a physical force to cause mechanical motion or to hold against some reaction. This force is produced by magnetic flux linking the coil, magnetic structure and armature. This magnetic flux is produced by a magnetic pressure or magneto-motive force. For a particular magnetic structure with a specific air gap this magnetic pressure is evaluated in terms of ampere-turns.

The calculation in detail of the ampere-turns required for a given magnetic circuit presents a complicated problem involving a consideration of the saturation properties of the iron with varying reluctance of different sections as well as the effect of air gap. However, where air gaps are present the resultant flux is largely determined by the reluctance or magnetic resistance of the air gap. For a given air gap it is possible, therefore, to arrive at a rough approximation of the ampere-turns required to produce a given flux and resultant force. For this analysis of the problem, it is assumed that all the ampere-turns are used entirely in overcoming the magnetic reluctance of the air gap. This assumption is

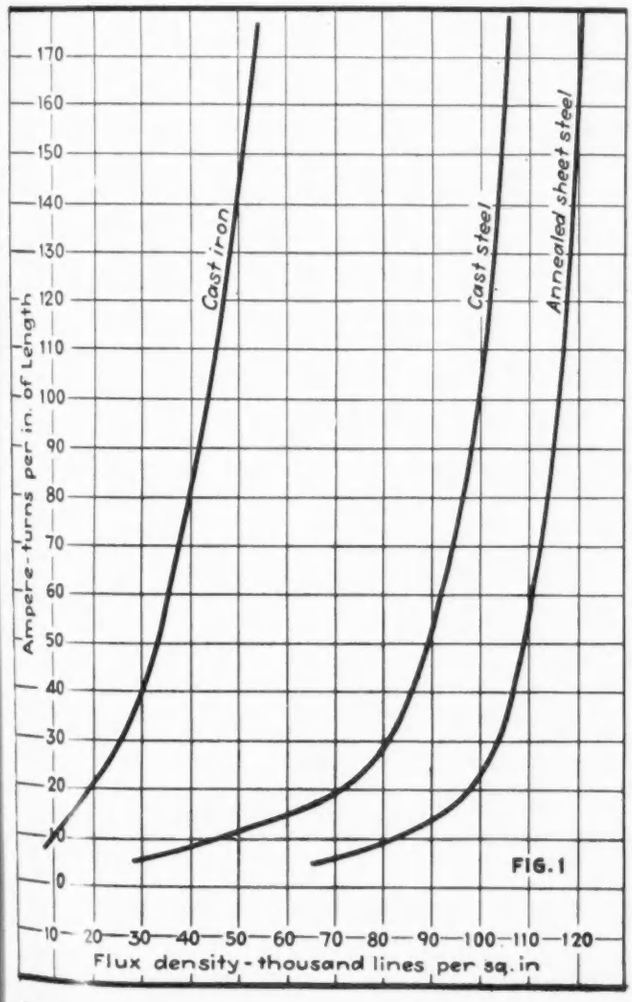


Fig. 1—Typical saturation curves of standard magnetic materials showing relation between flux density and ampere-turns

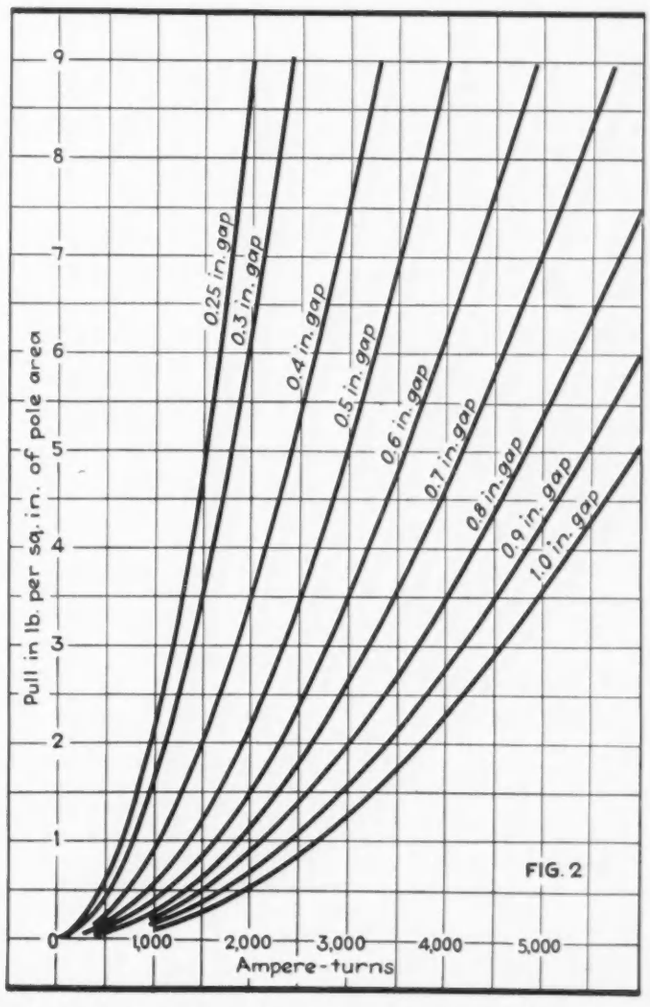


Fig. 2—Air gap pull in lb. per sq.in. of pole area of magnets at various air gap lengths for different ampere-turns

approximately correct as long as the iron is not used at a flux density above the "knee" of its saturation curve. Typical saturation curves are shown in Fig. 1 for standard magnetic materials.

Where AT = ampere turns
F = force in lb.
B = flux density in lines per sq. in.
ϕ = total flux
a = area in sq. in. of one pole face (assuming both pole faces are the same)
L = length of air gap in in.

The air gap pull of any electro-magnet can be approximated from

$$F = \frac{B^2 \times a}{72,130,000} \qquad (1)$$

The ampere-turns required to produce a given total flux can be calculated from

$$AT = \frac{\phi \times L}{a \times 3.192} \qquad (2)$$

Combining Equations (1) and (2) and substituting for ϕ its value aB the ampere-turns required to produce a given air gap pull can be estimated as follows:

$$AT = 2,660 \times L \times \sqrt{\frac{F}{a}} \qquad (3)$$

Ampere-turns against lb. pull per sq. in. of pole face are plotted in the curves of Fig. 2 for various air gaps.

These data should be used only as a guide in the preliminary determination of the various factors. More accurate methods are extremely complicated and even these generally require checking by test on the final magnetic circuit.

Magnetic coils can be divided into two general classes according to construction; namely, (1) those wound in spools and, (2) those wound on tubes in such a manner that they are self-supporting without end washers. Spools may be either molded complete or built-up from tubes and end washers cemented or bonded together with resinous materials. In general the built-up spool uses a double tube construction, an inner tube serving as the mechanical support and an outer one as a seal tube separating the end washers. All spools for coils wound "straight-up" in a single section are provided with a "starting washer" in addition to the end washers, with a slot for bringing the starting lead from the bottom layer to the outer surface. Sometimes instead of a separate slotted "starting washer," one end washer has a grooved recess for bringing out the starting lead. A typical molded spool construction is shown in Fig. 3, the construction of a built-up spool is also shown.

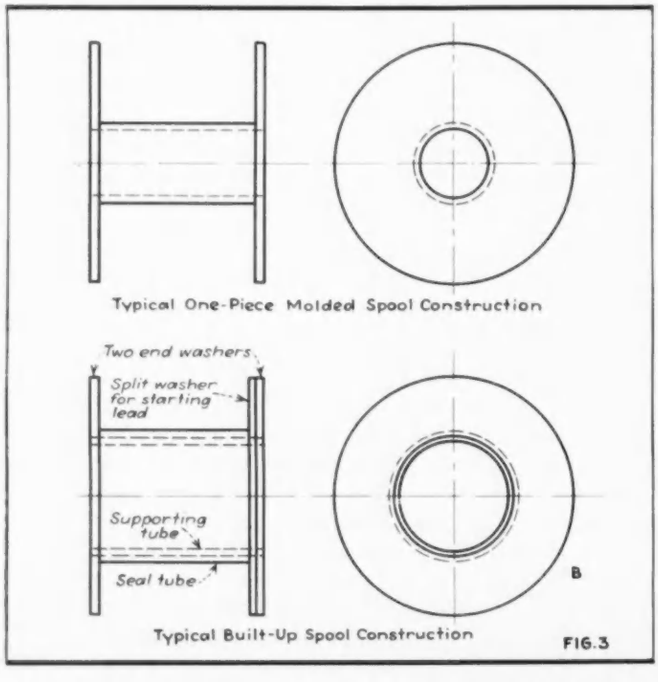


Fig. 3—Typical one-piece and built-up spool constructions for magnet coils

"Self sustained" coils are those wound in "Universal" automatic winding machines, usually with enameled wire. They can be wound on a single thin wall insulating tube and need no end washers for mechanical support. While the turns are wound in a close spiral the machine winds one or more cotton threads in an open spiral so that the cotton lies diagonally along the barrel surface. The interlacing cotton overlaps the wire travel at each end and builds up a cotton wall. This performs the dual purpose of supporting the winding and providing an insulating barrier at the ends. Sometimes, particularly on coils for over 250 volts, end washers are added to furnish more positive mechanical separation of the coil from the adjacent apparatus. On this type of coil no slotted "starting washer" is needed, the starting lead is usually insulated by wrapping it with treated cloth and then embedding it in the cotton end wall.

On spool type coils a certain amount of extra space is needed for tube wall thickness and for the starting washer while on "self-sustained" coils the cotton wall occupies approximately $\frac{1}{8}$ in. at each end. On long coils the winding space lost because of the presence of the cotton wall is of little importance but on short coils it may be prohibitive. On short coils with few turns per layer and on coils of wire larger than No. 20 A.W.G., spool construction is usually preferable. Coils using No. 20 wire or finer should generally be of the "self-sustained" type wherever length permits, because of the lower cost obtained with the automatic winding machines.

Another form of self-sustained coil is that wound on automatic machines with paper between layers. This is satisfactory where a high voltage between layers is encountered particularly on coils using very fine wire. However, the space factor usually is not as good as on other types of winding.

In general it is desirable to use spool wound coils on higher voltages particularly where creepage to ground is a serious problem. However, "Universal" wound coils with end washers properly cemented on are used very successfully on 600 volt d.c. service. Where proper equipment and trained personnel are available universal winding has proven satisfactory on all coils wound with enameled wire from No. 20 A.W.G. and smaller. With wire larger than No. 20 A.W.G., spool wound coils are preferable and the wire should generally be wound in even layers.

PRODUCT ENGINEERING ✦ REFERENCE BOOK SHEET